Preservice science teachers' metaphors on the subject of genetically modified organisms

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Contents

Abstract

The present study aimed to evaluate the use of metaphors by preservice science teachers on the subject of genetically modified organisms (GMOs). In the study, a phenomenology method was employed in the scope of a qualitative research model. The study group was composed of 189 preservice teachers who were employed in various science fields (e.g., biology, physics, chemistry, science) at a state university during the spring semester of the 2016 to 2017 academic year. In the form used for data collection, the preservice teachers were asked to fill in the following query: 'GMO is like …… because ……'. The data collected in this scope were analysed with frequency (f) and percentage (%) calculations and the results derived from these analyses were listed in tables. It was determined that, among the 189 preservice teachers, 150 valid metaphors were generated, while 39 were invalid. The metaphors gathered with the query posed in the first section of the data collection process were grouped into six categories according to their similarities and common characteristics, as follows: Causing changes in appearance or structure; having harmful effects; having beneficial effects; having harmful effects though seemingly beneficial ones at first glance; having both beneficial and harmful effects; and having harmful effects that occur over time. The largest number of metaphors was found in the 'causing changes in appearance or structure' category, with a value of f = 51, while the smallest number of metaphors was found in the 'having beneficial effects' category, with a value of f = 6. From this study, it was determined that a large number of preservice teachers have negative perceptions as well as some misconceptions of the concept of GMOs.

Keywords: Genetically modified organism (GMO), metaphor, preservice science teachers.

Introduction

Today, in order to create successful and productive societies, individuals must learn about the processes of learning, thinking, and how to use technology for the benefit of people (Hançer, 2007). In this regard, individuals are expected to investigate and

question the information they receive rather than simply accepting it as truth without further consideration and to use metacognitive skills when faced with problems so that they can meet the needs of the current era (Balım & Ormancı, 2012). All of these expectations are among the basic goals and objectives of science education. It could be stated that the technological and scientific development levels of societies including individuals equipped with these skills will rise over time. Developments in the field of science and technology have important effects on the functions of the environment, societies, and individuals. Therefore, developments in the field of science and technology are influential in a number of areas such as in managing environmental problems, genetic diseases, agriculture, and so on. Today, there are increasing efforts to enhance agricultural production and animal production in line with the growing global human population. It is thought that the world's population will exceed eight billion by 2025 and that 95% of this increase will occur in developed countries (Çetiner, 2004). However, the rate of population growth has not been paralleled so far by the rate of production of foods to meet the needs of the projected population size. Therefore, for such reasons as the population growth, the decreasing rate of farmlands, and food waste, famine and poverty problems are now thought to threaten human beings (Arda, 1994; Phillips, 2008). The decreasing number of natural sources has led to development of different technologies for food production (Yeşilbağ, 2004). Of note, recent occurrences in the fields of biotechnology and genetic engineering have made it possible to transfer genes between living beings. These advancements are expected to allow for the removal of most of the negative effects seen in food technology, agriculture, and ecology. Among these developments, the most popular one is the creation of genetically modified organisms (GMOs). According to the World Health Organization (2005) 'a GMO is created by changing the gene sequence of the original living organism with the help of gene technologies or … by adding new traits to a living organism with the transfer of genes with different traits from viruses, bacteria, plants, or animals' . In related literature, organisms obtained using genetic engineering are called one of the following: genetically modified products, GMOs, transgenetic organisms, bioengineering organisms, and so on (Uzogara, 2000).

GMOs exist in many areas in our lives and are used in a number of foods we consume. Numerous foods such as baby foods, fried foods, meat, fish, dairy products, fruits and vegetables, frozen foods, canned foods, candies, sauces, biscuits, pudding, vegetable oils, medicine, hormones, vaccines, and so on all can be produced with the help of this method (Çelik & Balık, 2007; Phillips, 2008; Takeda & Matsuoka, 2008; Topal, 2004). The use of foods produced with GMOs could be a solution to the nutrition problems present in the world today, but many people are also concerned about the safety of these foods (Claybourne, 2007). Some individuals believe that genetically modified plants and animals will have a negative influence on the

ecological balance as well as on the health of living beings and that they will be dependent on monopolized companies selling seeds. The probable negative effects of products and organisms obtained with this technology are claimed to include allergic reactions caused by GMO products, their toxic effects, their negative effects on ecology, and risks related to genetic diversity (Çelik & Balık, 2007; Muir & Howard, 1999; Tüysüzoğlu, & Gülsaçan, 2004).

Establishing the subject more pervasively in science education will increase the permanency of people's knowledge on the topic. Furthermore, if science subjects are taught based on metaphors, then students' learning will become more meaningful and permanent. Metaphors can be defined as a tool that concretizes abstract concepts and which helps individuals to learn difficult-to-remember information via schemes in the mind with the use of fewer words (Yücel Cengiz, 2016).

Metaphors can also be defined as a powerful mental tool that individuals can use to explain abstract and complex phenomena (Saban, Koçbeker & Saban, 2006). Metaphors are considered to be an individual's way of perceiving of the world. Individuals make use of metaphors while defining their own feelings and thoughts as well as others', which makes their consideration helpful in becoming informed about individuals' ways of perceiving themselves and others (Girmen, 2007). In addition, metaphors allow for one to give meaning to unknown phenomena with the help of more concrete and previously experienced phenomena so that novel abstract and complex concepts can be explained. Metaphors do not simply refer to figures of speech used in daily life but rather cover more than that (Saban, Koçbeker, & Saban, 2006).

In our daily life, while explaining most concepts, we either attempt to make a concept we want to explain resemble another one we have experienced before or we consider and highlight the common aspects of two concepts; in this way, we use metaphors, which have been regarded in recent years as the basic mechanism of reasoning (Ocak & Gündüz, 2006). In this respect, people make use of metaphors and similes while explaining a number of situations in their daily lives in order to strengthen their expression and conveyance of information. Specifically, the situation or phenomenon that the individual wants to explain will be explained better if it is likened to or compared with another one by place emphasis on certain features (Şişman, 2002).

Today, GMOs are commonly used in many areas including industry, agriculture, and health, and the concept concerns all individuals in terms of its socioscientific aspects as well as effects on human and environment (Tanır, 2005). In the present study, the metaphor method requiring metacognitive thinking was used to reveal preservice teachers' perceptions regarding GMOs, a very popular and constantly developing

subject. This study is considered to be important since it tried to reveal preservice teachers' perceptions regarding GMOs and to determine the correctness of their knowledge about GMOs. In this regard, revealing science preservice teachers' perceptions regarding GMOs with the help of metaphors is thought to contribute to the related literature.

The following research questions were established, in line with the purpose of the study:

What are the metaphors used by preservice science teachers to explain the concept of GMOs?

Which categorie(s) do the preservice science teachers' metaphors belong to?

Method

Research Model

The present study, which aimed to reveal the nature of preservice science teachers' metaphors regarding GMOs, was desgined using the qualitative research method. Qualitative studies are defined as studies that involve a process of revealing perceptions and phenomena in their natural environments in a realistic and holistic manner (Yıldırım & Şimşek, 2011). In this study, the phenomenology model, one of the existing qualitative research designs, was used. In this phenomenology model, the purpose was to reveal the perceptions via a specific phenomenon and to classify these perceptions into conceptual categories (Marton, 1986). For this reason, the phenomenology method was employed to determine the meanings given by the preservice science teachers to the concept of GMOs and to reveal their perceptions regarding this topic.

Study Group

The study group was made up of preservice teachers from the fields of science (e.g., chemistry, physics, biology and science) who were part of the education faculty of a state university during the spring term of the academic year of 2016 to 2017. The study group included preservice teachers from the first, second, third, and fifth class years in the department of Biology Education; from the first, second, and fifth class years in the department of Chemistry Education; from the third and fifth class years in the department of Physics Education; and from the first, second, third, and fourth class years in the department of Science Education. There were no preservice teachers from the fourth class year in Biology Education; from the third and fourth

class years in Chemistry Education; or from the first, second, and fourth class years in Physics Education involved in this research. In the study, while determining the study group, the criteria sampling method, one of the purposeful sampling methods, was used. The participants in the study were determined to be science preservice teachers because they were more appropriate to the research purpose, because GMOs is a subject taught more intensively in the fields of science and because science teachers' perceptions regarding GMOs are more likely to have an influence on the perceptions and opinions of their current and future students.

Table 1 presents the frequencies (f) and percentages (%) regarding the science preservice teachers participating in the study with respect to the variables of department and gender.

Table 1. Distribution of the preservice teachers who make up the study group with respect to certain variables

Department of the Preservice Teachers	f	%	Female	Male
Science Education	96	50.79	81	15
Biology Education	43	22.75	33	10
Chemistry Education	25	13.23	21	4
Physics Education	25	13.23	21	4
Total	**189**		**156**	**33**

Data Collection Tool

For the development of the data collection tool used in the present study, other research efforts on metaphors were reviewed (Derman, 2013; Ekici, 2016; Gedikli, 2014; Karaşahinoğlu, 2015; Tatar and Murat, 2011; Uyanık, 2012; Uzunkol, 2012; Yapıcı, 2015; Yücel Cengiz, 2016) and, based on these studies, the data collection tool was developed in line with the views of faculty members from the department of Biology Education and considering the opinions of experts in the field of measurement and evaluation. The form prepared included questions regarding personal information about the included preservice teachers such as their department, class year, and gender. In the form, the open-ended question ('GMO is like ……. because …….') was presented to the preservice teachers with a request for them to supply what they deemed to be appropriate metaphors. In order to let the participants justify their metaphors, the word 'because' was included in the statement.

Data Analysis

The research data collected in the study were analysed using the content analysis method. The basic purpose of content analysis is to identifty the concepts and relationships in order to explain the data collected. Of note, the concepts and themes that appear unrecognizable in descriptive analysis can be identified more easily here, since these concepts and themes are subjected to a more in-depth procedure in content analysis (Yıldırım & Şimşek, 2011).

While analysing the data, the phases followed were (1) coding/eliminating, (2) classification, (3) category development, (4) ensuring validity and reliability, and (5) transferring the data into the computer.

Phase of Coding / Elimination: In this phase, first, each form filled in by each participant was coded and numbered as P1, P2, P3, and so on, and the metaphors produced by the participants were examined. Forms that did not serve the purpose of this study as well as those that had no connection with the subject and those that were incompletely filled out were not included in the data analysis. Therefore, the responses of 39 participants to the first part of the form were excluded, as these participants failed to report metaphors that were appropriate to the research purpose. Consequently, a total of 150 metaphors were found to be appropriate.

Phase of Classification: When the 150 metaphors found appropriate were examined, it was seen that 117 of them were different metaphors. These metaphors were grouped according to their similarities and differences.

Phase of Category Development: In this phase, the groups formed were associated with a theme in accordance with their similar features, and categories were formed. Considering the similar features of the metaphors determined, the metaphors were stratified within six different categories, as follows: 'causing changes in appearance or structure', 'having harmful effects,, 'having beneficial effects', having harmful effects though seemingly beneficial ones at first glance', 'having both beneficial and harmful effects,, and 'having harmful effects that occur over time.'

Phase of Ensuring Validity and Reliability: In this phase, for reliability issues, a field expert was asked for their views in order to determine whether the metaphors separated into the six conceptual categories obtained in the study each cohesively represented a clear conceptual category. As a result, considering the consensus and disagreement between the expert and the researcher, the reliability was calculated as 0.93 using the formula put forward by Miles and Huberman (1994).

Phase of Data Transfer into the Computer Environment: After all of the data were transferred into the computer environment, the frequencies (f) and percentages (%) were calculated and presented in tables.

Findings

When the data were examined, it was seen that most of the participants tried to explain the idea of GMO products using such substances as hormones, medicines, and additives. In addition, they described GMO products as bigger, more puffed, smoother, or more shapeless when compared with their typical non-GMO states. These descriptions revealed that the majority of preservice teachers surveyed in this investigation held misconceptions regarding GMO. When the metaphors produced by the preservice teachers were examined, it was found that they also predominantly had negative opinions and judgements presumably due to a lack of related knowledge.

Table 2 presents the frequencies (f) and percentages (%) regarding the metaphors produced by the preservice teachers.

Table 2. Metaphors produced by the preservice teachers regarding GMOs

Metaphor	f	%	Metaphor	f	%
Tomato	5	3.33	Bottle full of alcohol	1	0.67
Poison	4	2.67	Empty can	1	0.67
Balloon	4	2.67	Empty box	1	0.67
Human	3	2	Pomegranate with no seeds in it	1	0.67
Obese person	3	2	Dependent person	1	0.67
Woman with make-up	3	2	Winter tomato	1	0.67
Virus	3	2	Decorated but empty box	1	0.67
Aesthetics	3	2	Old cheap car looking like BMW	1	0.67
Watermelon	3	2	Sweet appearance with bitter taste	1	0.67
Mobile phone made in China	2	1.33	Being poisoned	1	0.67
Two-faced person	2	1.33	Packed biscuit	1	0.67
Cancer	2	1.33	Poisonous cake	1	0.67
Plastics	2	1.33	Poisonous apple	1	0.67
Parasite	2	1.33	Person with views changed	1	0.67
Weapon	2	1.33	Nice-looking, worn-out building	1	0.67
Stale bread	2	1.33	Broken watch	1	0.67
Rotten apple	2	1.33	Tasteless onion with a beautiful appearance	1	0.67
Chameleon	2	1.33	Quicksilver	1	0.67
Leading to death	2	1.33	Microbe	1	0.67
Person with botox done	2	1.33	Artificial flower	1	0.67
Grave	1	0.67	Blow-dried hair	1	0.67
Murderers looking like foods	1	0.67	Poisonous substance	1	0.67
Illness	1	0.67	Basketball ball	1	0.67
Clostridium botulium	1	0.67	Softly-speaking bad person	1	0.67

Chemical weapon	1	0.67	Modified cheap car	1	0.67
Rotten food	1	0.67	Diamond	1	0.67
Poisonous mushroom	1	0.67	Perfect corn	1	0.67
Acid	1	0.67	Antibiotic	1	0.67
Harmful substance	1	0.67	Artificial vegetable–fruit	1	0.67
Harmful bacteria	1	0.67	Smart phone	1	0.67
Rotten ferment	1	0.67	Neutral	1	0.67
Nuclear power station	1	0.67	Slurry	1	0.67
Drug killing the human	1	0.67	Adding sugar to beans	1	0.67
Zombie	1	0.67	Placing a gene into the DNA of a plant or animal	1	0.67
Unnecessarily-used medicine	1	0.67	Rodent insect gnawing the human body	1	0.67
Bomb	1	0.67	Sofa with decaying legs	1	0.67
Watermelon without taste	1	0.67	Wormy intestine	1	0.67
Ball	1	0.67	Technology	1	0.67
Toy	1	0.67	Bomb ready to explode	1	0.67
Shapeless items	1	0.67	Wormy tree	1	0.67
Tomato with a different shape	1	0.67	Potato with increased weight	1	0.67
Cube-shaped watermelon	1	0.67	Sweet corn	1	0.67
Deformity	1	0.67	Perfect	1	0.67
Artificial substance	1	0.67	Beautiful apple	1	0.67
Olive with a white seed	1	0.67	Smooth apples in appearance	1	0.67
Gorilla	1	0.67	Rice lacking vitamin	1	0.67
Broken fridge	1	0.67	Messy room	1	0.67
Doll	1	0.67	Blue big strawberry	1	0.67
Mega sponge	1	0.67	G-mail password changed	1	0.67
Human with hormone intake	1	0.67	Pen without ink	1	0.67
Rotten or artificial vegetable–fruit	1	0.67	Lie	1	0.67
Puffed chicken	1	0.67	Mutation	1	0.67
Cloning	1	0.67	Old woman with aesthetic operation	1	0.67
Vegetables	1	0.67	Scentless rose	1	0.67
Smooth vegetables and fruits in appearance	1	0.67	Fat tomato	1	0.67
Object losing its originality	1	0.67	Banana with a different shape	1	0.67
Something different from its original form	1	0.67	Chemical event	1	0.67
Living being with its natural structure distorted	1	0.67	Watermelon looking like a pumpkin	1	0.67
Bogy	1	0.67			
			Total	**150**	

As can be seen in Table 2, a total of 150 appropriate metaphors were produced by the preservice teachers, and 117 of them were different metaphors. The most frequent

metaphors were 'tomato (f = 5, 3.33%)'; 'poison, balloon (f = 4, 2.67%)'; 'human, obese person, woman with make-up, virus, aesthetics, watermelon (f = 3, 2%)'; and 'mobile phone made in China, two-faced person, cancer, plastic, parasite, weapon, stale bread, rotten apple, chameleon, leading to death, person with botulinum toxin injections done (f = 2, 1.33%)'. Each of the other metaphors was different and used only once (f = 1, 0.67%).

Categories Including the Metaphors with Similar Features Produced by the Science Preservice Teachers

The metaphors produced by the participants were gathered under six categories with respect to the similar features of the metaphors, as mentioned previously. When the metaphors were classified depending on their similar features, it was seen that some of the preservice teachers produced the same metaphors; however, due to the reasons for use of these metaphors as stated by the preservice teachers in the explanation part, these metaphors were thought to belong to different categories. As an example, below, two of the preservice teachers used the same metaphor, but the two instances were included in different categories because the reasons for their use were different.

> "GMOs are like a poison because all of the foods we eat include poison, which really harms us. We suffer from illnesses more" (P63).
>
> "GMOs are like a poison because people consuming GMO products will certainly be exposed to its harms in the long-term, though they may not experience its harms in the short-term. Like products with agricultural pesticides, GMOs lead to illnesses and even to death" (P3).

As one of the preservice teachers here (coded as P63) stated that GMOs cause harm just like a poison, the metaphor produced by this participant was allotted to the category of 'having harmful effects', while, when the same metaphor was used by a different preservice teacher (coded as P3), it was attributed to the category of 'having harmful effects that occur over time' due to this participant thinking that GMOs would be harmful over time, though the negative effects may not occur instantly.

As explained previously, when the metaphors produced by the preservice teachers were examined, it was seen that the metaphors could be gathered under six categories with respect to the similar and common features of the metaphors. Table 3 demonstrates the categories and the related frequencies and percentages.

Table 3. Categories of the Metaphors Produced by the Preservice Teachers Regarding the Concept of GMOs

Conceptual Categories	f	%
Causing changes in appearance or structure	51	34.00
Having harmful effects though seemingly beneficial ones at first glance	43	28.67
Having harmful effects	29	19.33
Having harmful effects that occur over time	12	8.00
Having both beneficial and harmful effects	9	6.00
Having beneficial effects	6	4.00
Total	**150**	

When Table 3 is examined, it is seen that the most frequent metaphor belonged to the category of 'causing changes in appearance or structure' (f = 51, 34%) and that the least frequent metaphor belonged to the category of 'having beneficial effects' (f = 6, 4%).

When the names of the categories were examined, it was seen that four of the six categories included the word 'harm'. The reason for this could be the fact that most of the preservice teachers' metaphors regarding GMOs included statements related to their perceived negative or harmful aspects.

Category 1: Causing changes in appearance or structure

The metaphors used by the preservice teachers to state that there was a change in the appearances and structures of foods with GMOs included were gathered under this category. This category included metaphors used to report that there were changes in the appearance or the genetic structure of the living being and that the living being acquired new traits that it did not have previously. When the category of 'causing changes in appearance or structure' was examined, it was seen that most of the preservice teachers perceived GMO products to be different in appearance, shapeless, bigger, or smoother when compared to their usual forms and they also pointed out that people eating foods with GMOs have different physical appearances. Table 4 presents the metaphors belonging to this category.

Table 4. Metaphors Produced by the Preservice Teachers Regarding the Concept of GMOs in the Category of 'Causing Changes in Appearance or Structure'

Metaphor	f	%	Metaphor	f	%
Tomato	4	7.84	Toy	1	1.96
Balloon	3	5.88	Shapeless items	1	1.96
Watermelon	3	5.88	Tomato with a different shape	1	1.96
Chameleon	2	3.92	Cube-shaped watermelon	1	1.96
Aesthetics	2	3.92	Person with botulinum toxin injections done	1	1.96

Messy room	1	1.96	Deformity	1	1.96
Blue big strawberry	1	1.96	Artificial substance	1	1.96
G-mail password changed	1	1.96	Human	1	1.96
Obese person	1	1.96	Olive with a white seed	1	1.96
Pen without ink	1	1.96	Gorilla	1	1.96
Lie	1	1.96	Stale bread	1	1.96
Mutation	1	1.96	Broken fridge	1	1.96
Scentless rose	1	1.96	Rotten apple	1	1.96
Fat tomato	1	1.96	Doll	1	1.96
Banana with a different shape	1	1.96	Sponge	1	1.96
Chemical event	1	1.96	Human with hormone intake	1	1.96
Watermelon looking like a pumpkin	1	1.96	Cloning	1	1.96
Living being with its natural structure distorted	1	1.96	Vegetables	1	1.96
Plastic	1	1.96	Smooth vegetables and fruits in appearance	1	1.96
Rotten or artificial vegetable–fruit	1	1.96	Object losing its originality	1	1.96
Puffed chicken	1	1.96	Something different from its original form	1	1.96
			Total	**51**	

When Table 4 is examined, it can be noted that this category included a total of 51 metaphors and that 42 of them were unique from one another. The most frequent metaphors in this category were 'tomato' (n = 4), 'watermelon' (n = 3), 'balloon' (n = 3), 'aesthetics' (n = 2), and 'chameleon' (n = 2).

A few reasons for why some of the preservice teachers used these metaphors regarding GMOs in this category are as follows:

> "GMO is like a blue big strawberry because its natural organism is distorted since its gene has been modified; thus, it now has an unusual shape, size, and colour" (P2).

> "GMO is like an obese person because it is so different from its original appearance that it is really hard to recognize. Likewise, the use of GMOs makes it almost impossible to recognize that fruit or vegetable" (P5).

> "GMO is like a chemical event because, in a chemical event, we make changes in substances and get the desired result. If the gene of a living being is changed, then it will never be as it was in the past" (P58).

"GMO is like a tomato because a tomato likes water and it is not prolific at all in a waterless environment. With the transfer of genes taken from desert plants to a tomato plant, it may become resistant to drought and thus become prolific" (P54).

"GMO is like aesthetics because when aesthetics are constantly applied, the physical appearance will change completely, losing its original appearance" (P75).

Category 2: Having harmful effects though seemingly beneficial ones at first glance

The metaphors used to state that GMO products actually have harmful effects though they seem to be as if they were beneficial initially were gathered under this category. When the metaphors belonging to this category were examined, it was seen that, according to the participants, GMO products initially had beautiful, appealing, and attractive appearances but that these products were actually useless or even harmful in the end. The preservice teachers generally reported that the physical appearances of GMO products were misleading and that these products had the potential to have harmful effects on living beings. Table 5 presents the metaphors belonging to the category of 'having harmful effects though seemingly beneficial ones at first glance'.

Table 5. Metaphors Produced by the Preservice Teachers Regarding the Concept of GMOs in the Category of 'Having Harmful Effects Though Seemingly Beneficial Ones at First Glance'

Metaphor	f	%	Metaphor	f	%
Woman with make-up	3	6.98	Poisonous apple	1	2.33
Mobile phone made in China	2	4.65	Person with views changed	1	2.33
Two-faced person	2	4.65	Nice-looking worn-out building	1	2.33
Old woman with aesthetic operation	1	2.33	Broken watch	1	2.33
Human	1	2.33	Tasteless onion with a beautiful appearance	1	2.33
Watermelon looking like a pumpkin	1	2.33	Quicksilver	1	2.33
Ball	1	2.33	Microbe	1	2.33
Bottle full of alcohol	1	2.33	Artificial flower	1	2.33
Empty can	1	2.33	Blow-dried hair	1	2.33
Empty box	1	2.33	Poisonous substance	1	2.33
Pomegranate with no seeds in it	1	2.33	Basketball	1	2.33
Dependent person	1	2.33	Obese person	1	2.33
Winter tomato	1	2.33	Leading to death	1	2.33

Decorated but empty box	1	2.33	Person with botulinum toxin injections done	1	2.33
Old cheap car looking like BMW	1	2.33	Softly-speaking bad person	1	2.33
Sweet appearance with bitter taste	1	2.33	Tomato	1	2.33
Balloon	1	2.33	Modified cheap car	1	2.33
Packed biscuit	1	2.33	Diamond	1	2.33
Poisonous cake	1	2.33	Perfect corn	1	2.33
Aesthetics					
			Total	43	

When Table 5 is examined, it can be observed that this category included the second highest number of metaphors out of the six categories included in this research. In this category, there were 43 metaphors in total, and 39 of them were different from one another. The most frequent metaphors in this category were "woman with make-up" (n = 3), "mobile phone made in China" (n = 2), and "two-faced person" (n = 2), respectively. Below are some examples of the metaphors and the reasons for why the preservice teachers reported them.

> "GMO is like an old woman with [an] aesthetic operation because her appearance has been made beautiful thanks to [the] operation, but her organs and cells are still old" (P35).

> "GMO is like a mobile phone made in China because it looks beautiful, but it does not work. GMOs are something like that. As GMO products are genetically modified, they are not natural. I mean, they are fake" (P51).

> "GMO is like a two-faced person because, when the organism is genetically modified, you cannot realize this change. It is seriously harmful to human health" (P67).

> "GMO is like something with a sweet appearance but a bitter taste because fruits have different shapes, and we may see tasteless fruits and vegetables but with beautiful appearances" (P106).

Category 3: Having harmful effects

The metaphors reported on the topic of the harmful effects of GMO foods belong to this category. When the reasons for stating these metaphors in this category were examined, it was seen that, according to the preservice teachers, GMO products cause people to suffer from illnesses, a shortened human lifespan, and high rates of

obesity. Table 6 presents the metaphors produced by the preservice teachers in this category.

Table 6. Metaphors Produced by the Preservice Teachers Regarding the Concept of GMOs in the Category of 'Having Harmful Effects'

Metaphor	**f**	**%**
Virus	3	10.34
Poison	2	6.90
Bogy	1	3.45
Grave	1	3.45
Murderers looking like foods	1	3.45
İllness	1	3.45
C.botulium	1	3.45
Chemical weapon	1	3.45
Rotten food	1	3.45
Obese person	1	3.45
Poisonous mushroom	1	3.45
Acid	1	3.45
Harmful substance	1	3.45
Plastic	1	3.45
Harmful bacteria	1	3.45
Rotten ferment	1	3.45
Rotten apple	1	3.45
Nuclear power station	1	3.45
Weapon	1	3.45
Drug killing the human	1	3.45
Zombie	1	3.45
Unnecessarily-used medicine	1	3.45
Being poisoned	1	3.45
Leading to death	1	3.45
Bomb	1	3.45
Cancer	1	3.45
Total	**29**	

In Table 6, it can be seen that there were 29 metaphors attributed to this category, with 26 being distinctive. The most frequent metaphors were virus (n = 3) and poison (n = 2). Each of the other metaphors was used only once, and they were all different. Below are some examples of the metaphors and the reasons for why the preservice teachers produced them.

> "GMO is like an acid because, when you pour acid onto a substance, it harms that substance, just as GMOs harm people" (P59).

"GMO is like a poisonbecause all of the foods we eat include poisons that harm us. As a result, we suffer from illnesses more" (P63).

"GMO is like a bomb because it harms our body in all respects" (P171).

"GMO is like a cancer because these products cause changes in the human defence mechanism and lead to an increase in diseases" (P186).

Category 4: Having harmful effects that occur over time

The metaphors regarding the long-term harmful effects of GMO foods were gathered under this category. In other words, this category included metaphors produced by the participants to suggest that GMO products did not have any observable harmful effects at the beginning, but then later caused various negative effects on the human body over time. Table 7 below presents the frequencies and percentages related to the metaphors produced within this category.

Table 7. Metaphors Produced by the Preservice Teachers in relation to the Concept of GMOs for the Category of 'Having Harmful Effects That Occur Over Time'

Metaphor	f	%
Parasite	2	16.67
Poison	2	16.67
Stale bread	1	8.33
Rodent or insect gnawing on the human body	1	8.33
Sofa with decaying legs	1	8.33
Cancer	1	8.33
Wormy intestine	1	8.33
Technology	1	8.33
Bomb ready to explode	1	8.33
Wormy tree	1	8.33
Total	**12**	

In reviewing Table 7, 12 metaphors were noted to be part of this category. Among these metaphors, 10 of them were different, with poison (n = 2) and parasite (n = 2) being the most frequent metaphors used. Below are some examples of the metaphors and the reasons for why the preservice teachers produced them.

"GMO is like a poison because related research shows that GMOs are quite harmful with bad effects on people and that their use results in cancer and slowly leads to death" (P46).

"GMO is like a rodent or insect gnawing on the human body because the GMO foods we eat are exposed to agricultural pesticides without waiting for the process of natural maturation, and they cause various illnesses over time, as they never leave the human body. Though these foods may not seem to have any observable harms at the beginning, they could have a poisonous effect in future" (P24).

Category 5: Having both beneficial and harmful effects

Metaphors used by the preservice teachers to mean that GMO foods were both beneficial and harmful belonged to this category. Table 8 shows these metaphors.

Table 8. Metaphors Produced by the Preservice Teachers in Relation to the Concept of GMOs for the Category of 'Having Both Beneficial and Harmful Effects'

Metaphor	f	%
Antibiotic	1	11.11
Weapon	1	11.11
Human	1	11.11
Artificial vegetable–fruit	1	11.11
Smartphone	1	11.11
Neutral	1	11.11
Slurry	1	11.11
Adding sugar to beans	1	11.11
Placing a gene into the DNA of a plant or animal	1	11.11
Total	**9**	

When Table 8 is examined, it is seen that there were nine metaphors placed in this category. Notably, all of the metaphors belonging to this category were different from one another. It was revealed that the preservice teachers surveyed found GMOs to be beneficial in terms of providing a remedy for famine, obtaining more products in a shorter period of time, and having a beautiful appearance, while they considered GMOs to be harmful with respect to being harmful to human health, leading to illnesses, and changing the tastes of foods. Below are some examples of the metaphors and the reasons for why the preservice teachers suggested them.

"GMO is like an antibiotic because, besides its benefits, it also gives harm. In some cases, we do not give importance to its harms. It allows us to obtain more products in a shorter period of time, but harms us due to the distorted natural structure of the food. The reason for why I compared it to an antibiotic is that, when used too much, an antibiotic is also harmful to our health' (P14).

"GMO is like a human: it may be beneficial as well as harmful for us as a result of various factors. It may be a friend of us or an enemy' (P22).

"GMO is like a smartphonebecause one can benefit from it or may suffer from its harmful side effects as well" (P125).

Category 6: Having beneficial effects

The metaphors used by the preservice teachers to indicate the benefits of GMO were gathered under this category. In this category, there were only a few metaphors produced by the participants. The preservice teachers thought that GMOs increased the nutritive value of foods, allowed for the obtaining of more products in a shorter period of time, and beautified the colours and shapes of foods. Table 9 presents the related metaphors.

Table 9. Metaphors Produced by the Preservice Teachers in Relation to the Concept of GMOs for the Category of 'Having Beneficial Effects'

Metaphor	f	%
Potato with increased weight	1	16.6
Sweet corn	1	16.6
Perfect	1	16.6
Beautiful apple	1	16.6
Smooth apples in appearance	1	16.6
Rice lacking vitamins	1	16.6
Total	**6**	

When Table 9 is examined, it can be seen that only six metaphors were included in this category, and all of them were different from each other. Some examples of the metaphors and the reasons why the preservice teachers produced were as follows:

"GMO is like rice lacking vitamins, because adding genes to the rice will help to increase the vitamin content" (P61).

"GMO is like something perfect because, by modifying an apple genetically, one can have an apple with perfect colour, shape, and appearance. I mean, you can make it more attractive by changing its appearance using GMOs" (P137).

Discussion and Conclusion

The present study, which was carried out by way of a phenomenology design, one of the existing qualitative research methods, aimed to determine science preservice teachers' metaphors regarding the concept of GMOs. In the study, a total of 150 metaphors produced by 189 participants were identified. In similar studies reported in the related literature, metaphors regarding various concepts like mathematics, biology, laboratory, and so on (Polat, 2010; Yapıcı, 2015; Yücel Cengiz, 2016) were also noted. Furthermore, in similar studies, Uzunkol (2012) and Gürbüzoğlu Yalmancı (2015) tried to determine the common metaphors shared regarding GMOs.

According to the examination of the GMO-related metaphors produced by the preservice science teachers as part of the present study, the preservice teachers surveyed mostly thought that the shapes and structures of the GMO-based products were different from their original forms; that these products harm living beings; and that they were actually harmful despite their initially perceived attractive appearances. Therefore, it could be stated that the preservice teachers involved in the present research mostly had negative and pessimistic perceptions regarding GMOs. In this study, it was found that the category with the most frequent metaphors was 'causing changes in appearance or structure (f = 51)', which was followed by 'having harmful effects though seemingly beneficial ones at first glance (f = 43)', 'having harmful effects (f = 29)', 'having harmful effects that occur over time (f = 12)', 'having both beneficial and harmful effects (f = 9)', and 'having beneficial effects (f = 6)', respectively. The metaphors used most by the preservice teachers included 'tomato' (f = 5); 'poison, balloon' (f = 4); 'human, obese person, woman with make-up, virus, aesthetic, watermelon (f = 3)'; and 'mobile phone made in China, two-faced person, cancer, plastic, parasite, weapon, stale bread, rotten apple, chameleon, leading to death, person with botulinum toxin injections done (f = 2)'. Metaphors being used by the preservice teachers such as 'plastic', 'artificial', 'fake', 'doll', and so on demonstrate that the preservice teachers did not find these products natural; the use of metaphors such as 'balloon' and 'ball' showed that the preservice teachers did not find the products beneficial; and the use of metaphors like 'poison', 'virus', 'parasite', and 'cancer' were used by the preservice teachers to state that the products were harmful. In the study, it was seen that the preservice teachers mostly gave examples related to the ideas of 'tomato' and 'watermelon', while explaining their reasons for why they had used these metaphors. In one study titled 'Analysis of Elementary School Preservice Teachers' Perceptions of Genetically Modified Organisms with the Help of Metaphors', Uzunkol (2012) found that the most frequent metaphor reported was used to show the harmful effects of GMO despite its seemingly beneficial appearance and that the least frequent metaphor reported was used to mention the benefits of GMO for humanity. In the study, it was also revealed that the elementary school preservice teachers surveyed mostly had negative perceptions.

In another study titled 'High School Students' Perceptions Regarding Genetically Modified Organisms', Gürbüzoğlu Yalmancı (2015) found that the most frequent metaphor reported was used to mention the change in the appearance of the product and that the least frequent metaphor reported was used to mention the harmful effects of the product despite its seemingly beneficial appearance at first glance. Furthermore, the results reported in other related literature are consistent with those obtained in the present study. Sönmez and Kılınç (2012), in their study titled 'Science and Technology Preservice Teachers' Self-efficacies Regarding GMO Foods: Probable Effects of Certain Psychometric Factors', reported that 72% of the preservice teachers demonstrated negative attitudes towards GMOs, with the accompanying belief that such disturbed the natural balance of things.

Interestingly, in the present study, it was found that, in most of the metaphors, the preservice teachers preferred mentioning herbal products while explaining GMOs and that, in a few metaphors, the preservice teachers mentioned the effects of GMOs on animals. This situation shows that most of the participants considered genetic modification to be limited to plants. When the metaphors produced by the preservice teachers and the explanations related to these metaphors were examined further, it was seen that the preservice teachers had a large amount of incorrect knowledge about GMOs; that they believed that GMOs had many harmful effects; and that they did not have sufficient knowledge about the associated benefits. In addition, the preservice teachers' lack of knowledge about GMOs and their misconceptions regarding GMOs caused them to think that hormone and additives were added to many vegetables and fruits; that GMO foods were more smooth or shapeless in appearance as compared with natural products; and that the bodies of people consuming GMO foods trended toward demonstrating more unusual physical appearances. A living being whose gene sequence is changed using gene technologies or who gains new traits with the transfer of different genes from a virus, bacteria, plants, or animals is called a 'genetically modified organism' (World Health Organization, 2005). In this respect, it is not true that GMO products include hormones or additives. As can be understood from this definition, genetic modification is also not just limited to plants. Genetic transfer is possible in viruses, bacteria, and animals as well. Furthermore, hormones or pesticides are not injected into the living being; in addition, it is not true that GMO products will be different from their natural counterparts.

Öztürk, Ağapınar Şahin, and Güdü Tüfekçi (2014), in their study, revealed that 56.5% of participants considered GMO foods to include hormones. This result supports the noted misconceptions of the preservice teachers in the present study regarding that GMO foods included hormones, pesticides, or unnatural additives.

In another study, Özden et al. (2013) found that the participants surveyed had positive views about biotechnology and GMOs in terms of their use for the sake of enhancing human health and medicine production, but that they were opposed to the genetic modification of plants and animals for all purposes. In this respect, similar to the findings obtained in the present study, most of the other studies in the related literature reported negative attitudes towards GMOs. In addition, studies conducted on the topic of GMOs demonstrated that different study groups (e.g., students, preservice teachers, teachers, and so on) mostly had a lack of knowledge and negative views about GMOs. This finding is more important when the study group includes preservice teachers. Considering the fact that preservice teachers with negative views and perceptions regarding GMO will give incorrect information to their future students and cause them also to develop negative perceptions, it is necessary to provide preservice teachers with correct information about GMOs.

In the present study, it was seen that the preservice teachers surveyed produced very few similar metaphors amongst themselves. This situation was largely due to the fact that the preservice teachers had different experiences and thus perceptions regarding GMOs. Therefore, it could be stated that each participant produced so many different metaphors just because they perceived GMOs from unique perspectives. In this study, 117 of all the 150 metaphors were different not only due to the different perspectives of the participants but also due to the richness of the comparisons used.

Teachers have a fairly important role in ensuring the goals set forth in an education system are achieved. To this end, the perceptions and attitudes of preservice teachers, who will become teachers in future, will have a direct influence on their experiences with students and the thoughts and opinions of those students. The findings obtained in the present study revealed that the preservice teachers had a significant lack of knowledge about GMOs. For this reason, the results of the present study could be said to provide feedback regarding preservice teachers' levels of knowledge, misconceptions, and negative attitudes regarding GMO, which is a socioscientific and currently relevant subject. In order to determine the reasons for these teachers' related misconceptions, future studies could be designed using different research methods.

In order to avoid the dissemination of such incorrect information and negative perceptions regarding GMOs in all areas of society, teachers must be able to provide correct information about GMOs to their students starting from their early school years onwards. For this purpose, preservice teachers should be equipped with correct information about GMOs. In this respect, preservice teachers' lack of knowledge and misconceptions regarding GMOs can be avoided if the curricula applied at education faculties included more biotechnology subjects. In addition, when the importance of metaphors in education is taken into account, a greater use of metaphors could be

involved more in the teaching and learning process to reveal preservice teachers' perceptions and to enable them explain concepts more easily and correctly.

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