MOJES MALAYSIAN ONLINE JOURNAL OF EDUCATIONAL SCIENCES OCTOBER 2023, 11 (4)

DETERMINATION OF MISCONCEPTIONS ABOUT CARBOHYDRATES

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ABSTRACT

Concepts are the essential elements of basic sciences. For meaningful learning, these concepts need to be expressed clearly and accurately. Before the teaching methods and techniques are used, the concepts' definitions, limitations, and exceptions should be explained. Therefore, the purpose of this research was to determine whether the definition of carbohydrates is made in the books or not and to determine what characteristics of carbohydrates are used by students and biology teachers to define carbohydrates. The concept of "carbohydrate" was chosen within the research scope. Case study research, one of the qualitative research methods, was used. A purposive sampling technique was used in sample selection. The participants included in the study were selected from pre-service science teachers, molecular biology and genetics students, and biology teachers working in various schools. Open-ended questions and books were used to collect data. To analyze the data, content analysis was used. In light of the data obtained from the books and students, it was determined whether the definition was adequately expressed. As a result of the research, it was concluded that the participants expressed generalizations while defining carbohydrates. When defining carbohydrates, the definitions stated with a maximum percentage were energy sources, the elements in its structure (C, H, and O), and the molecular formula ($C_n(H_2O)_n$). In addition, it was determined that the definition of carbohydrates in the textbooks is not made thoroughly and is expressed based on general characteristics. It can be said that general expressions rather than definitions can cause difficulties in learning concepts and establishing relationships between concepts. The explanations made with generalizations confuse classifying the properties that fit the definition or not.

Keywords: *Misconception, Carbohydrates, Textbooks, Biology*

INTRODUCTION

Biology, which deals with living things, is a scientific field consisting of basic and complex subjects. It has a common denominator with many disciplines and encompasses many sub-disciplines, mainly biochemistry, biophysics, cytology, biotechnology, and plant physiology. Biology subjects in school grades are organized at various levels. Each subject is taught at various levels of complexity in biology lessons. While some are given in depth and detail, some are transferred to students superficially (Lazarowitz & Penso, 1992). Students who participate in learning face all the stated fields and subjects and must learn many concepts related to each subject or topic (Leonard et al., 2014). Due to superficially taught concepts, some biology concepts are challenging to learn. It was stated that the students had difficulties expressing concepts they did not understand (Lazarowitz & Penso, 1992). While learning these concepts, teachers and textbooks are among the most commonly used resources by students at every stage of the education level. The concepts must be learned correctly for learning to occur permanently and correctly. Possible misconceptions should be corrected with scientific facts. The misconception may be defined as scientifically inaccurate facts (Leonard et al., 2014). Misconceptions about some information that students learn from their experiences or in the formal process form a barrier to learning scientific knowledge and make it difficult to understand (Andariana et al., 2020; Hammer, 1996; Tekkaya, 2002). Given this situation, an intense effort is made to identify and eliminate misconceptions (Amir & Tamir, 1994). Along with the developments and innovations in the field of education, there are developments to eliminate misconceptions with new technologies and methods (Bahar, 2003; Queloz et al., 2017). Misconceptions may arise for various reasons, including prior knowledge, textbooks, and knowledge from teachers (Soyibo, 1995). When students learn new information, they construct on the knowledge they have (Kumandaş et al., 2019).

In some books, errors and misconceptions can be encountered in various subjects (Soyibo, 1995; Storey, 1991, 1992). Although errors and misconceptions are different concepts, they are related. Errors refer to inaccuracies, while misunderstandings arise while misconceptions arise due to misunderstanding (Arnawa et al., 2019). In this context, misconceptions will be taken into consideration. Errors and misconceptions have been identified in some topics, from fundamental to complex subjects in biology (Soyibo, 1995). Researchers who conduct research in this field eliminate these errors and misconceptions. Correcting the misconceptions in the books can take many years because errors and misconceptions in the textbooks are determined slowly (Storey, 1991, 1992). Teachers have an essential place in correcting misconceptions that are found in textbooks. However, for teachers to correct these misconceptions, they need to know the situations that cause or may cause misconceptions. They should have sufficient knowledge to correct the misconceptions in their assessments and lessons. Having knowledge of the content and transferring the concepts to the students based on scientific facts will eliminate possible misconceptions (Andariana et al., 2020; Bahar, 2003; Brown & Schwartz, 2009; Gomez-Zwiep, 2008; Kalas et al., 2013).

Textbooks are the most critical resources constantly referred to by students. In addition, teachers constantly use textbooks while teaching (Kajander & Lovric, 2009). In particular, the teacher's correct definition of scientific concepts is the first important learning step because it is associated with other concepts according to the learned concept. Learning occurs with the knowledge we have, and new knowledge is constructed. Learning will become permanent and meaningful if the concepts are built on scientific facts (Amir & Tamir, 1994; Badenhorst et al., 2016; Brown & Schwartz, 2009; Nakhleh, 1992; Podsakoff et al., 2016; Vinner, 1983). When the student constructs a concept incorrectly, it becomes challenging to correct it again (Milenkovic et al., 2016). Therefore, teachers should express the main components, exceptions, similarities, and differences of each definition of a concept related to the topic.

In identifying teachers and book-based misconceptions, two of the most critical elements in preventing and providing solutions, ensures that knowledge is learned more accurately. Researchers have emphasized the importance of studies conducted to identify misconceptions originating from textbooks and teachers. Especially in places where opportunities are limited, students access information mostly from textbooks (Dikmenli et al., 2009). Learning concepts (Klymkowsky & Garvin-Doxas, 2008) and

revealing students' misconceptions (Modell et al., 2005) were generally carried out to identify misconceptions that exist according to various school levels (Gomez-Zwiep, 2008).

Many studies have been carried out on biology subjects to determine misconceptions, mainly including photosynthesis (Brown & Schwartz, 2009; Galvin & Mooney Simmie, 2015), cell (Hala et al., 2018; Suwono et al., 2021), acids and bases (Ross & Munby, 1991), cell division (Dikmenli, 2010), metabolism (Oliveira et al., 2003) and protein synthesis (Fisher, 1985). In other words, research has been carried out on fundamental to complex subjects (Kumandaş et al., 2019; Soyibo, 1995; Tekkaya, 2002; Yip, 1998). Many misconceptions originating from textbooks and teachers have been identified (Soyibo, 1995). Suwono et al. (2021) showed that the pre-service teachers' conceptual knowledge about cells was insufficient. Carbohydrates are also one of the primary subjects of biology and research has been done on this subject. A lot of misconceptions have been identified about carbohydrates, though there is not enough research on this subject. A test was developed to identify misconceptions about carbohydrates. This test was applied to the students attending the organic chemistry course. It was determined that students have misconceptions about this subject (Milenkovic et al., 2016). Similarly, Koç and Sönmez (2018) determined that there are misconceptions about the components, structures, importance for living things, classification, types, and bond structures of carbohydrates. In order to identify misconceptions, data can be collected by many methods such as open-ended questions, multiple-choice test questions, and interviews. However, one of the effective strategies is to do more than one application about a particular concept. Thus, in-depth data can be collected. It can enable the development of more creative methods to correct misconceptions (Amir & Tamir, 1994). Therefore, this study, different from the studies on carbohydrates, aimed to focus on the definition of the concept of carbohydrates. Research was conducted to determine the possible pre-service teachers' misconceptions due to the lack of a clear definition of carbohydrates. In addition, by analyzing textbooks used at schools, it was determined whether the concept of carbohydrates was used in the books, and which features of carbohydrates were emphasized. By comparing the results, the reasons for the concept-based misconception were identified. The purpose of this research was to determine whether the definition of carbohydrates is made in the books or not and to determine what characteristics of carbohydrates are used by the pre-service science teachers, molecular biology and genetics students, and biology teachers to define carbohydrates. In this context, answers to the following questions were investigated:

- Is there a clear definition of carbohydrates in the selected books?
- Do participants appropriately express the definition of carbohydrates?
- According to which properties of carbohydrates do the participants identify?

METHODOLOGY

This study was conducted in the Spring semester of 2019. Case study research, one of the qualitative research methods, was used (McMillan & Schumacher, 2009). It involves the in-depth study of a phenomenon or event. As it is an in-depth study, it allows the researcher to use a variety of data collection tools (Priya, 2021). The research consists of two parts: document analysis and data collection with open-ended questions.

Participants

The participants included in the study were selected from pre-service science teachers (N: 67), molecular biology and genetics-MBG (N: 80) students, and biology teachers (BTs) working in various schools (N: 22). PST, MBG, and BT were used to denote the abbreviations of "pre-service science teachers," "molecular biology and genetics," and "biology teachers," respectively. A purposive sampling technique was used in sample selection. It was assumed that they had previously taken a course on carbohydrates. Generally, university biology courses are taken in the first and second years. Therefore, fourth-year students and biology teachers were preferred.

Book Analysis

The second part of the research includes book analysis. The books taught at the university and used as supplementary resources (N=5) and the 9th-grade biology textbook taught as a textbook in high school

were included in the study (N=1). The books included in the research were coded as B1=*Life: The Science of Biology* (Sadava et al., 2014), B2=Campbell *Biology* (Reece et al., 2013), B3=*General Botany* (Kadıoğlu & Kaya, 2009), B4=*Biology-I* (Efe, 2005), B5=*General Biology-I* (Starr & Taggart, 2005), and B6=*9th Grade Biology* (Dereli, 2022). In these books, it was determined that carbohydrate was clearly expressed, its definition was made, and which properties were emphasized while defining this compound. As the scope of the subject, the introductory parts where the concept was introduced were considered and analyzed.

Data Tools

An open-ended questionnaire was designed as a data collection tool. Open-ended questions are widely used for reflecting the shape existing in the participants' minds on paper (Geer, 1988). The following processes were followed in the development of open-ended questions. Preparation of the questions, obtaining expert opinions on the prepared questions (three experts from biochemistry, science, and biology education), making the necessary corrections as a result of the expert opinion, conducting the pilot study (3rd-grade pre-service teachers from the science department), and the final version (Kurniawan et al., 2018). The open-ended question form consists of three questions (Appendix 1). Participants were asked to define carbohydrates. In addition, they were given a compound whose molecular formula was similar to carbohydrates and asked to explain whether it was a carbohydrate or not.

Data Analysis

An analysis form consisting of seven items, including the properties of carbohydrates, was used for the data analysis. The general properties of carbohydrates were considered in the creation of the items. These items represent analysis codes. Initially, the codes were determined as 10; some codes were grouped under similar codes in line with expert opinion. The basic expressions, including general properties, were considered in the book's section about carbohydrates. The answers given by the participants were applied to content analysis according to the scale, including the properties of carbohydrates. The data were arranged as percentage-frequency.

Validity and Reliability

In order to determine the agreement between the evaluators, it was evaluated by the same researcher at two different times, and the agreement value was calculated as 85% for book analysis and 89% for participants' answers. These values are acceptable in the literature for inter-rater reliability (Bruck et al., 2008).

FINDINGS

When the books are analyzed in general, carbohydrates are explained in detail in B1 and B2 books. Carbohydrates are expressed in all dimensions. The definition of carbohydrates was given only in books coded B2 and B5. In other books, the definition is not clearly expressed. The elements it contains, and the components related to the general formula were expressed in most books. Books coded B1 and B4 state, "The general formula of carbohydrates is $C_n(H_2O)_n$". However, this feature belongs to monosaccharides.

"*The structure of glucose is typical of the general structure of sugars. This molecule contains a single carbonyl group (=C=O) and numerous hydroxyl groups. Depending on the position of the carbonyl group, the sugar is either an aldose (aldehyde sugar) or a ketose (ketone sugar)* (B2, p. 64)."

"*Monosaccharides contain two or more hydroxyl (-OH) groups and an aldehyde or ketone group* (B5, p. 18)."

The subject of monosaccharides is also included in both books (B2 and B5), in which the definition is included. The concept was evaluated in terms of monosaccharides. In general, the information given in the books is "*Monosaccharides have the general formula* $C_n(H_2O)_n$" and "*Carbohydrates consist of*

carbon, hydrogen and oxygen." Emphasizing this information intensively in textbooks may cause misconceptions.

"..... *The general formula of carbohydrates is $C_n(H_2O)_n$, in which the carbons are aqueous (the relationship between water molecules and carbon is the ratio $C_1H_2O_1$), and this is where they got their name* (B1, p. 49)."

"*The simplest organic compounds are carbohydrates. They have C, H, and O in their structure. Their ratios are in the form of CH_2O. Monosaccharides (simple sugars). .....Simple sugars are of great biological importance. They are shown with the formula $C_nH_{2n}O_n$* (B4, p 25)."

"Carbohydrates are organic compounds of carbon, oxygen, and hydrogen elements (B3, p. 28)."

Table 1

Textbooks analysis results

Compounds	B1	B2	B3	B4	B5	B6
Polyhydroxy aldehydes *or* ketones	-	+	-	-	+	-
Aldehyde or ketone functional group	+	+	-	+	-	-
Carbohydrates have the general formula $C_n(H_2O)_n$	+	-	-	+	-	-
Monosaccharides have the general formula $C_n(H_2O)_n$	+	+	+	-	-	+
Carbohydrates are composed of carbon, hydrogen, and oxygen	+	+	-	+	-	+

B1=Life: The Science of Biology (Sadava et al., 2014), B2=: Campbell Biology (Reece et al., 2013), B3= General Botany (Kadıoğlu & Kaya, 2009), B4: Biology-I(Efe, 2005), B5: General Biology-I (Starr & Taggart, 2005), and B6=9th Grade Biology Textbook (Dereli, 2022).

As shown in Figure 1, it was determined that the expressions used by the participants with the highest percentage while defining carbohydrates were related to being a source of energy (28%), the elements in its structure (27%), and the molecular formula (32%). It can be said that the answers given by the highest percentage of all participants are similar. On the other hand, it is seen that the percentage related to the expression "polyhydroxy aldehydes or ketones," which is the most critical component of the definition of carbohydrates, is at the lowest percentage (1%) in pre-service science teachers. This value was determined as 3% in molecular biology and genetics students. Biology teachers expressed carbohydrates with similar generalizations as pre-service teachers. Among the highest percentages were the elements in their structure (21%), energy source (17%), and the molecular formula (23%). It was determined that the component expressed by the participants with the lowest percentage was the "Glycoside bond" (MBG: 5 %; PST: 2 %; BT: 8 %). It was determined that all participants had the highest percentage in the component related to the molecular formula (MBG: 27%; PST: 32%; BT: 23%). It can be said that "Molecular formula-$C_nH_2O_n$" was among the expressions the participants used the most to define carbohydrates. However, another explanation used by the researchers while defining carbohydrates is "the elements (C, H, O, N, S, and P) in its structure" (MBG: 26%; PST: 27%; BT: 21%).

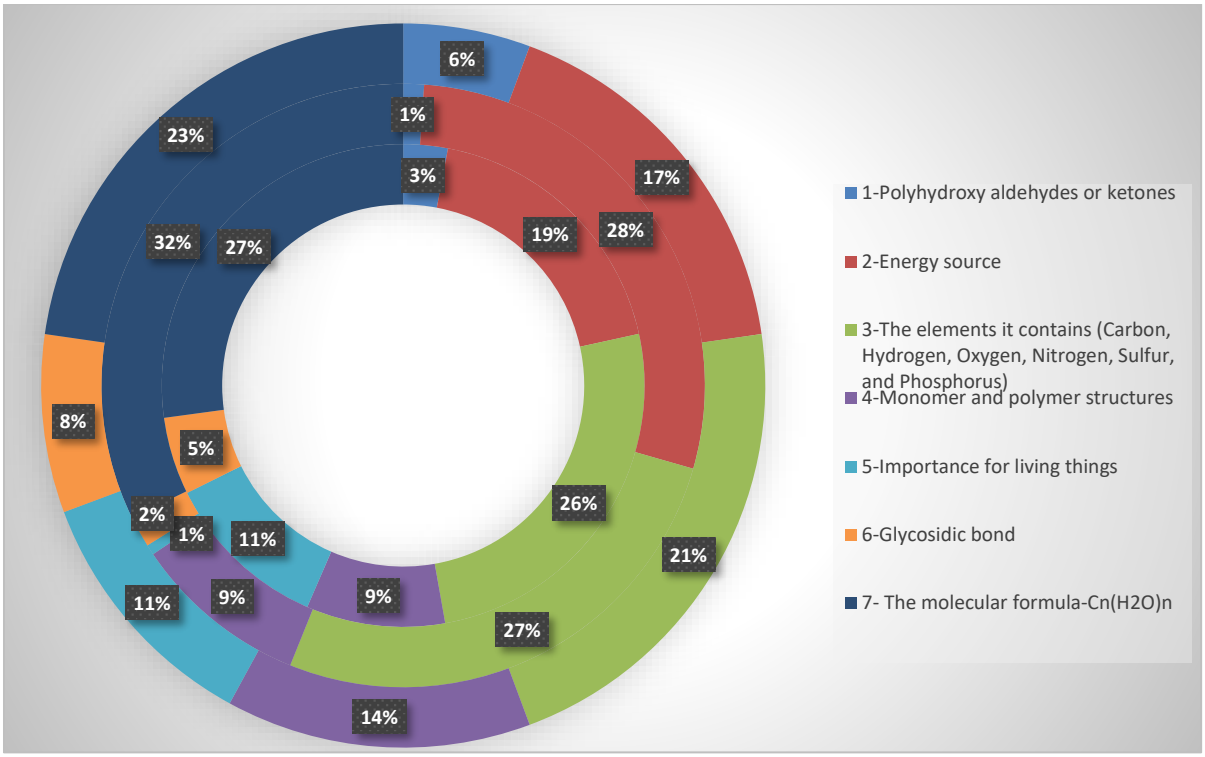


Figure 1. *Distribution of the answers given by the participants to the open-ended questions (MBG: inner, PST: Middle, BT: Outer).*

When the answers related to the compound whose molecular and structural formula were given were analyzed, the majority of the participants defined the given compound as a carbohydrate. They stated that accepting it as a carbohydrate was due to the elements in its structure and molecular formula. The most participants answered that it has a $C_n(H2O)_n$ structure (50.8%). Considering the findings obtained from pre-service science teachers and molecular biology and genetics students, these values have the highest percentage. The students identified the molecular formula with the status of being a carbohydrate. It was found that pre-service teachers and MBG students had a meager percentage associated with the most crucial component of the definition, "Polyhydrochis aldehyde or ketone" (PST: 0.81%; MBG: 4.85%). Similarly, the rate of those who said it is not a carbohydrate is also very low (PST: 7,46%; MBG: 8,64%). Most biology teachers marked the answer as carbohydrate (77.27%). They stated that the reasons for this were the molecular formula (45.65%) and the elements in its structure (43.48%). The teachers did not emphasize the concept and tried to express carbohydrates with general features. However, the highest percentage of those who said it is not carbohydrate was given by biology teachers (18.18%).

Table 2

Distribution of the answers given to the second question

		Yes %(f)	No %(f)	No idea %(f)
Carbohydrate	PST	89.55 (60)	7.46 (5)	2.99 (2)
	MBG	83.75 (67)	8.75 (7)	7.50 (6)

	BT	77.27 (17)	18,18 (4)	4.54 (1)
Reason for Question 2		% (f)		
1-Polyhydroxy aldehydes *or* ketones	PST	0.81 (1)		
	MBG	4.85 (5)		
	BT	10.87 (5)		
2-The elements it contains (C, H, O, S, N, and P)	PST	48.39 (60)		
	MBG	46.60 (48)		
	BT	43.48 (20)		
3-The molecular formula- $C_n(H_2O)_n$	PST	50.81 (63)		
	MBG	48.54 (50)		
	BT	45.65 (21)		

Some of the answers given by the participants in the study are given below. It can be said that the expressions used by pre-service teachers and biology teachers while defining carbohydrates are compatible with the information given in the books. The students' explanations show that general properties are widely used in the definition. The participants identified the concept of carbohydrates with the molecular formula. Similarly, it can be said that carbohydrates are defined based on the elements in their structure.

"*Carbohydrates are an important part of nutrition, which is the basic need of living things. They are obtained from food. It helps to provide the necessary energy to the living body* (PST 18)."

"*It consists of carbon, hydrogen, and oxygen. It is found in many foods. It is necessary for the human body* (PST 34)."

"*It is the first structure used when energy is needed in the cell. Its monomer is glucose. Bread is a type of carbohydrate. Carbohydrates contain C, H, and O in their structure* (MBG 52)."

"....."*Because the formula of carbohydrates is* $C_3H_6O_3$ (MBG 23)."

"*It is an organic compound among the basic components of living things. It is used as an energy source* (MBG 42)."

"*Carbohydrate refers to the structure of food. It is a type of nutritional value such as protein and fat. It is usually found in bakery products. Bread, pasta, chocolate, etc. When we consume it, it quickly increases the sugar in the blood. Therefore, we reach saturation quickly* (MBG 7)."

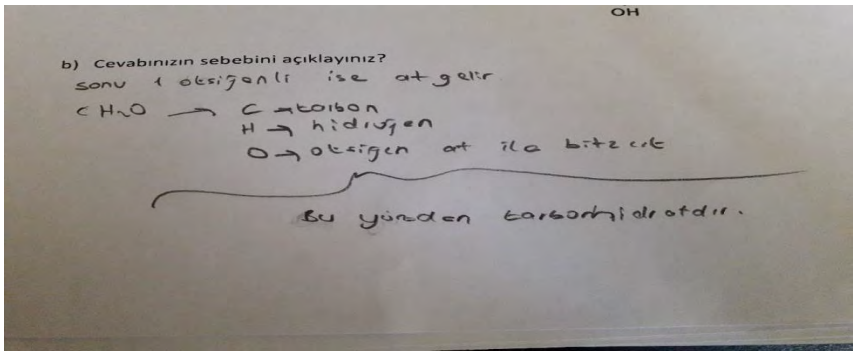
"*Carbohydrates are organic substances containing C, H, and O atoms in their structure. They are the first energy source used in the human body* (BT 8)."

"*It is a carbohydrate because it conforms to the sequence of the molecular formula* $C_nH_{2n}O_n$ (BT 11)."

"*It is a carbohydrate because its structural and molecular formula is similar to the molecular formula of carbohydrates* (BT 17)."

"*Because it contains C, H, and O atoms. The general formula of carbohydrates is* $C_nH_{2n}O_n$ (BT 3)."

Biology teacher's reason for explanation (BT 18);



Carbohydrate Definition Scheme (CDS)

Based on the definition of carbohydrates (Cole & Karner, 2016), a carbohydrate definition scheme (CDS) was created. This scheme was formed from four components by considering the definition's main features and the features emphasized by the textbooks and students. However, some examples of compounds that do and do not fit the definition scheme are given in Table 3.

Cole and Karner (2016) defined carbohydrates as "*Carbohydrates are polyhydroxy aldehydes or ketones or compounds that form polyhydroxy aldehydes and ketones when hydrolyzed* (p.157-164)".

As shown in Figure 2, it is seen that the concept of carbohydrates consists of many components. Each of these components is related to carbohydrates.

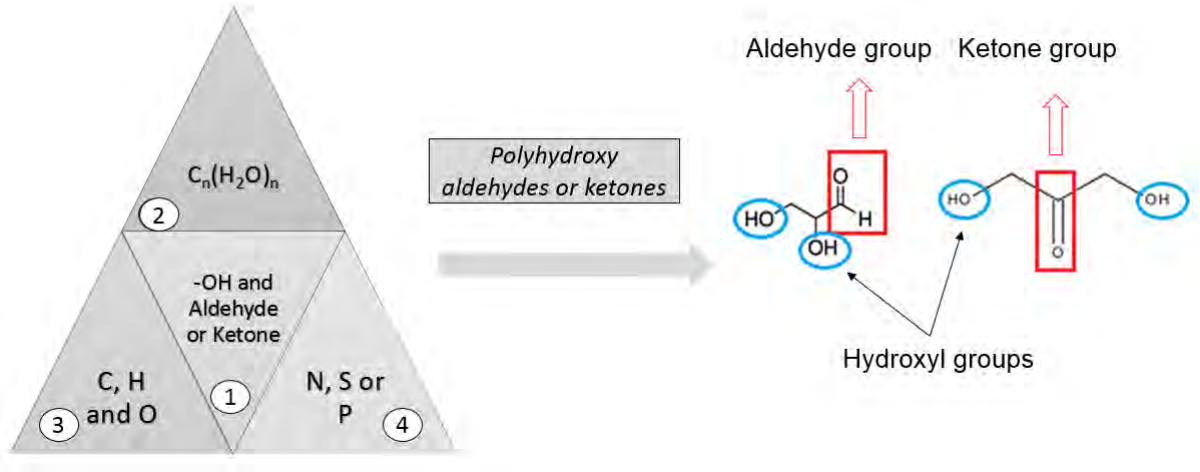
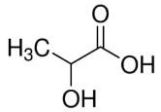
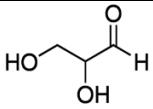
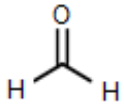
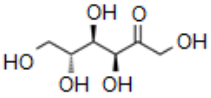
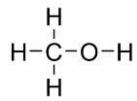
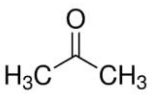
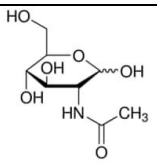
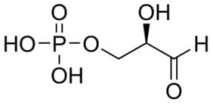


Figure 2. *Carbohydrate definition scheme*

Defining carbohydrates independently of hydroxyl groups and aldehyde/ketone groups is insufficient. This situation causes an incomplete definition of the concept. Concepts other than these two main components are among the properties of carbohydrates. However, it brings deficiencies while expressing the definition of carbohydrates. Defining carbohydrates in the formula $C_n(H_2O)_n$ structure leads to including compounds such as lactic acid, which are not carbohydrates, in the carbohydrate group. Similarly, as shown in Figure 2, expressing carbohydrates only with 2, 3, and 4 components causes deficiency or misconceptions (Lactic acid, Formaldehyde, Methanol, and Acetone). However, expressing only with 1 or with 1 and other components provides a more accurate definition. Saying that it consists only of aldehyde or ketone groups causes compounds such as formaldehyde and acetone to be classified

in the same group as carbohydrates. Similarly, the fact that it contains only hydroxyl groups (such as methanol and lactic acid) is not a sufficient parameter to be considered as a carbohydrate.

Table 3
The example of molecules and their chemical structure

Molecular name (Formula)	Lactic acid ($C_3H_6O_3$)	Glyceraldehyde ($C_3H_6O_3$)	Formaldehyde (CH_2O)	Fructose* ($C_6H_{12}O_6$)
Chemical Structure				
C, H, and O	✓	✓	✓	✓
$C_n(H_2O)_n$	✓	✓	✓	✓
Aldehyde group	-	✓	✓	-
Ketone group	-	-	-	✓
Hydroxyl (-OH) group	✓	✓	-	✓
Carbohydrate	No	Yes	No	Yes
Molecular name (Formula)	Methanol ** (CH_3OH)	Acetone (C_3H_6O)	N-acetylglucosamine ($C_8H_{15}NO_6$)	Glyceraldehyde 3-phosphate ($C_3H_7O_6P$)
Chemical Structure				
C, H, and O	✓	✓	✓	✓
N, P, or S	-	-	✓	✓
$C_n(H_2O)_n$	-	-	-	-
Aldehyde group	-	-	✓	✓
Ketone group	-	✓	-	-
Hydroxyl (-OH) group	✓	-	✓	✓
Carbohydrate	No	No	Yes	Yes

Addresses from which molecular formulas and structures are taken:
https://www.sigmaaldrich.com/TR/en, https://pubchem.ncbi.nlm.nih.gov/,
*http://www.chemspider.com/Chemical-Structure.5764.html (Fructose),
**https://biologydictionary.net/methanol/ (Methanol)

DISCUSSION

As can be seen from the answers obtained through textbooks and teachers, the main factor causing misconceptions is the lack of clear and explicit expression of concepts. Misconceptions or incomplete textbook information are transferred to students by students or teachers. Similarly, among the factors that cause misconceptions in studies, teacher and textbook-based reasons were stated (Duda et al., 2020; Gomez-Zwiep, 2008; Kalas et al., 2013; Klymkowsky & Garvin-Doxas, 2008; Suwono et al., 2021). This situation was explained with the chlorophyll experiment. Many books expressed a misconception that chlorophyll reflects green light. However, in experimental studies, it was determined that white and yellow leaves reflect green light more, although their chlorophyll content is very low (Virtanen et al., 2020).

It was seen that the missing information of the pre-service teachers was compatible with the parts neglected in the textbooks. It was determined that the lack of carbohydrate definition in the textbooks and the general features listed when defining carbohydrates were compatible with the answers given by the prospective teachers.

The misconceptions of pre-service teachers during the education process, insufficient knowledge about their fields, or lack of complete command of scientific concepts due to other reasons will be reflected negatively on their students in the future (Hala et al., 2018). A study on whether teachers understood the concepts correctly stated that physics, chemistry, and biology teachers could not express them in depth and with scientific explanations due to their superficial knowledge and misconceptions (Kikas, 2004). In the research conducted to determine the biology subjects students have difficulty learning, it was determined that genetics and water transport in plants were among the most challenging subjects. It was stated that the students could not learn the concepts of genetics thoroughly; the similarities and differences of the concepts were not understood, and therefore, they had difficulty in genetics. Students complained that much information and concepts must be learned (Bahar et al., 1999). This situation shows the importance of learning the concepts and transferring them to the students in an understandable way.

The most common features used by the participants when defining carbohydrates are that they are a source of energy, have CHO in their structure, and their general formula is $C_n(H_2O)_n$. These generalizations are also included in the books. The participants with the lowest percentage expressed "polyhydroxy aldehydes or ketones," which is the most critical feature of carbohydrates. Due to the definitions far from the basics of scientific knowledge, students have difficulty learning, constructing, or associating new concepts. Accordingly, learning becomes difficult (Modell et al., 2005). In the research conducted to determine the misconceptions of students in genetic concepts, it was stated that the students misdescribed basic genetic concepts. Genetic information was explained with different and related concepts. However, the concept of inheritance was also misdescribed by the majority of the participants (Machová & Ehler, 2021). This generalization misconception of pre-service teachers is likely to be transferred to students in the teaching process in the future. On the other hand, the properties listed about carbohydrates are not wrong statements. However, they cannot fully express the definition of carbohydrates. The properties numbered "2, 3, and 4" in Figure 2 are not only properties of carbohydrates. These compounds have general properties, and generalizations made using these compounds cause errors, as in the example below.

"*Carbohydrates are compounds that contain C, H, O and have CnH2nOn structure*."

It was stated that misconceptions arise due to generalizations about concepts, lack of terminology (Onder et al., 2017), and book errors (Barrass, 1984; Yates & Marek, 2014). A similar misunderstanding was found in the generalizations made on the cell subject. Although cells are similar in structure, animal and plant cells differ structurally. Therefore, if differences and similarities are not given comparatively, misunderstandings and misconceptions will arise when students use generalizations. When the basic features of the concepts are not fully understood, and exceptions are not given, teachers will transfer knowledge to students with the misconceptions they constantly have. However, they will not be able to realize the misconceptions in the textbooks (Barrass, 1984). It was stated that the prospective teachers had difficulty expressing and establishing relationships between the photosynthesis concepts. The probable reason is their knowledge of basic concepts is insufficient (Brown & Schwartz, 2009).

CONCLUSION

As a result, one of the most essential elements in teaching concepts is to express definitions clearly and accurately because definitions constitute the most critical elements of disciplines. Determining the possible misconceptions in the books in teacher training programs is of great importance. It is necessary to determine the misconceptions of the students who will take the role of teachers in the future. Although high school textbooks are designed according to the constructivist learning approach, teachers are the most important component to teach this information. However, the misconceptions in the basic level content of the high school textbooks need to be corrected. Moreover, the basic information in the chapter on carbohydrates in the 9th-grade textbook is given in a way that may cause misconceptions. Learning the basic information about a discipline facilitates the difficulties experienced in that field. Therefore, basic concepts should be learned and taught correctly by teachers (or books) (Modell et al., 2005). Thus, it becomes easier to make interpretations based on the existing concept and to construct new knowledge. In light of the findings obtained, expressing the concepts in the books precisely and correcting the existing misconceptions will prevent the formation of new misconceptions and contribute to meaningful learning for the students. In addition, generalized definitions may cause concept confusion. Giving exceptions and generalizations with various examples will be helpful while expressing the concepts. In order to provide more permanent and meaningful learning, it will be useful to reveal the primary and general features of the concepts in detail, include definitions that accurately express a concept in the books, and give these definitions in the subject introductions.

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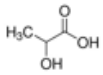
Appendix 1

<table>
<tr><td colspan="4">Question 1: What is the carbohydrate?

Answer 1:</td></tr>
<tr><td colspan="4">Question 2: Is the compound (the molecular formula and chemical structure are given below) a carbohydrate?

Molecular Formula: $C_3H_6O_3$ Chemical Structure:
  </td></tr>
<tr><td>Answer 2:</td><td>Yes</td><td>No</td><td>No idea</td></tr>
<tr><td colspan="4">Reason for answer 2:</td></tr>
</table>