A study on analogies used in new ninth grade biology textbook

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Abstract

Analogies have many advantages for students such as concretizing abstract concepts and enabling motivation. Analogies are frequently used in textbooks. Research shows that the analogies in textbooks are not used based on certain directives and sometimes lead to misconceptions for students. Therefore, analysing the analogies in textbooks on several dimensions will contribute to students and teachers. The purpose of this study is to analyse the types of analogies that are used in new ninth grade biology textbooks and examine how these analogies are structured and

presented. The examined textbook is used in the entire Turkey upon the approval of the Ministry of National Education. As a result of the analysis made based on the document examination technique, it was determined that analogies are more frequently used in the new biology textbook when compared to previous biology textbooks. It was also determined that analogies were structured in the functional, verbal, concrete-abstract, simple, and embedded activator types. It was also seen that the analogue explanation was insufficient and the limitations of the analogies were not specified as required.

Keywords: Analogy; Biology textbook; Biology education.

Introduction

Textbooks are important teaching materials that serve as a source for student learning in order to realize the purpose of teaching. Traditionally, textbooks are prepared for the purpose of enabling students to learn information regarding the topics of a lesson in an ordered and systematic way by themselves. Biology textbooks are prepared in line with effective planning and if used they can become effective teaching material in biology classes. As technology and information communication is rapidly developing today, educators have always taken textbooks into account as a good source of information for students. High school textbooks are one of the effective teaching materials that are frequently used in the process of teaching in education. Students and teachers highly believe in and rely on textbooks (Chiappetta, Ganesh, Lee and Phillips, 2006). The textbooks that are used by students and teachers need to be analysed at several dimensions so that education can achieve its purpose and students can make use of textbooks in the correct way. Analogies are one of the topics to be analysed in biology textbooks.

Biology textbooks and lessons handle a great number of concepts from processes at the molecular level such as DNA replication to ecosystems, which cover thousands of biotic and nonliving variables. Students are not directly able to visualize these concepts in the classroom environment but they can visualize them in their minds by creating models (Mclachlan, 2003). Analogies act as starting models for introducing science concepts. Analogies are one of the effective teaching tools that can be used in such cases. Analogies are powerful teaching tools that are commonly used in teaching science because analogies compare a new unfamiliar concept with an old familiar concept and make it comprehensible for students.

Analogy is the explanation of an unfamiliar concept by comparing it with a familiar concept. The unfamiliar concept is the target and the familiar concept is the analogue (Duit, 1991; Glynn, 1991; Dunbar, 2001). Scientists and science educators have used analogies in introducing or explaining many new concepts. Analogies compare the attributes of current conceptual knowledge in the student's mind and the knowledge to be acquired, and thus facilitate the comprehension of new concepts (Venville and Treagust, 1997). Analogies motivate students to engage in the topic and help students gain a new perspective about the topic for meaningful learning (Glynn and Takahashi, 1998; Heywood, 2002). Analogies help overcome misconceptions and play an important role in improving conceptual change (Brown and Clement, 1989; Stavy, 1991; Venville and Treagust, 1996). Analogies help students concretize abstract concepts (Thiele and Treagust, 1994).

Analogies are not always necessary and appropriate tools in teaching and they have some limitations. All analogies are not good analogies and all good analogies are not useful for all students (Orgill and Bodner, 2004). Furthermore, analogies never share all common attributes with the target concept and this can lead the students to misunderstand the target concept. And in some cases, students can be misled when the analogue concept replaces the target concept (Clement, 1993; Duit, Roth, Komorek and Wilbers, 2001; Orgill and Bodner, 2004). Gilbert (1989) reports that the use of analogy in biology lessons can lead to lack of success for students. Therefore, analogies should be distinctively selected and used. For these reasons, analogies should be used only when necessary and in an appropriate manner.

It is quite common to use analogies in biological texts. Glynn and Takahashi (1998) noted that biological texts that are promoted through analogies improved conceptual changes. Paris and Glynn (2004) determined that the analogy texts, in which the relations between the analogue and target concepts are clearly expressed and promoted through images, provided an advantage for pre-service teachers in transferring new knowledge from the familiar to the unfamiliar. The analogies in a textbook can lead to disadvantages if not used appropriately (Duit, 1991; Duit et al., 2001). Analogies never share all common attributes with the target concept. In some cases, analogue concept can replace the target concept and this can cause the students to misunderstand a target concept (Clement, 1993; Duit et al., 2001; Orgill & Bodner, 2004).

Textbooks are an important source of analogies (Parida and Goswami, 2000). The analogies in textbooks are freely used by students and teachers. The analogies in

textbooks are usually used randomly and can be insufficient for students (Gilbert, 1989). And this leads to misunderstandings for students most of the time (Thiele and Treagust, 1994). In this regard, some teaching models were developed for the effective use of analogies in teaching science education. Examples include the general model of analogy teaching (Zeitoun, 1984), the Teaching with Analogies (TWA) model (Glynn, 1991), and the Focus-Action-Reflection (FAR) model (Treagust, Harrison and Venville, 1998). The TWA model is the most commonly used among them. The TWA model explains the instructions to be followed by teachers in analogy-based teaching.

Curtis and Reigeluth (1984) developed an analogy classification system for analysis of analogies that are used in science textbooks. Thiele and Treagust (1994), on the other hand, expanded Curtis and Reigeluth's (1984) analogy classification system, and systematically classified the analogies used in secondary education chemistry textbooks. Thiele, Venville and Treagust (1995) analysed the analogies in secondary education biology textbooks and compared them with chemistry textbooks. Researchers claim that analogies were more frequently used in biology textbooks when compared to chemistry textbooks. Parida and Goswami (2000), analysing the analogies that are used in a science textbook, determined that although there were a great number of analogies in the examined textbook, most of them did not apply teaching with analogies models. Newton (2003) researched the analogies that are used in elementary school science textbooks and compared them with the analogies that are used in secondary education science textbooks. Orgill and Bodner (2006) analysed the analogies in college biochemistry textbooks. Dikmenli (2010) analysed the analogies in biology textbooks that were prepared according to previous secondary education biology curriculum.

Students either read the analogies in the textbooks or hear them through their teachers without filtering them. The analogies in the textbook gain more importance due to the teaching strategies that are traditionally applied in teacher-centred classrooms. Therefore, analysing the analogies that are used in biology textbooks will contribute much to students, teachers, textbook authors, and programmers. Analogies are commonly used within the textbooks. There are researchers that examine the role of instructional analogies within textbooks (Dikmenli, 2010; Paris and Glynn, 2004; Thiele and Treagust, 1994). Also, there were no studies that examined the analogies within the ninth grade biology textbook because this book is new.

Purpose

The purpose of this study is to analyse the types of analogies that are used in the new ninth grade biology textbooks in Turkey and examine how these analogies are structured and presented. Answers were sought for the following questions in line with this purpose.

- How often are analogies used in the new ninth grade biology textbook?
- What are the types and structures of the analogies used?

Method

The descriptive research method was used in this study. According to this method, the data obtained are summarized and interpreted based on previously determined categories. The data can be organized based on the categories presented by research questions and it can also be presented by taking the questions or dimensions that are used in the interview and observation processes. In the descriptive method, the purpose is to present the findings obtained to the reader in an organized and interpreted way. Therefore, data obtained are primarily described systematically. And then these descriptions are explained and interpreted. Cause-and-effect relationships are scrutinized and results are achieved (Yildirim and Simsek, 2005, p. 224).

The examined textbook

This research examines the new ninth grade biology textbook, which was prepared based on the secondary education biology curriculum that was revised in 2013 (Komisyon, 2014). This textbook is being used in the entire Turkey upon the approval of the Ministry of National Education.

Data collection and analysis

The document analyzing technique was used as the data collection method for this research. Document examination covers the analysis of the written materials that contain information about the phenomena or phenomenon that is targeted to be researched. In qualitative research, document examination can be a data collecting method alone or other data collecting methods can be used together. Which documents were important and which documents can be used as data sources were

closely associated with the research problem. For example, biology textbooks are one of the important data collecting tools in research that is related to biology education (Yildirim and Simsek, 2005, p. 187-188).

The biology textbook was read at least three times in detail and diagrams were reviewed in line with the purpose of the study. In the examination process, without judging if there are analogies or not, all simile and comparison types that are considered analogies were determined, coded, and photocopied. The coded simile types were read again from photocopies and then determined if they were analogies or not. The determined analogies were categorized based on the following criteria (Curtis and Reigeluth, 1984; Thiele and Treagust, 1994):

1. The level of target concept

Macroscopic: Involves target concepts that can be directly observed or detected through one or several sense organs.

Microscopic: Involves the target concepts that can be observed or detected only through the tools such as a microscope.

Sub-microscopic: Involves the target concepts that cannot be directly observed like atoms and molecules but explained through instructional models.

Symbolic: Involves the target concepts that can be explained through biological formula and symbols.

2. The analogical relationship between analogue and target

Structural: Analogue and target concepts in an analogy share similar attributes such as shape, size, colour, etc.

Functional: Analogue and target concepts in an analogy share similar attributes such as function, behaviour, etc.

Structural-functional: Analogue and target concepts in an analogy share both structural and functional attributes.

3. The presentation format

Verbal: The analogy is presented in the text in a verbal format only.

Pictorial-verbal: The analogy is presented in a verbal format along with a picture of the analogue.

4. The level of abstraction of the analogue and target concepts

Concrete-concrete: Both the analogue and target concepts are of a concrete nature.

Abstract-abstract: Both the analogue and target concepts are of an abstract nature.

Concrete-abstract: The analogue concept is of a concrete nature but the target concept is abstract.

5. The position of the analogue relevant to the target

Advance organizer: The analogue concept is presented in the text before the target concept.

Embedded activator: The analogue concept is presented in the text with the target concept.

Post-synthesizer: The analogue concept is presented in the text after the target concept.

6. The level of enrichment

Simple: Only one similarity is underlined between the analogue and target concepts. An analogy is formed from a simple sentence with no details.

Enriched: Two similarity dimensions between the analogue and target concepts are underlined. An analogical statement is formed from sentences that are basic for analogies.

Extended: Three or more similarity dimensions between the analogue and target concepts are emphasized. An analogical statement is formed from basic sentences including details. The analogies in which many sources have been used to explain a target concept are also considered extended analogies.

7. Pre-topic orientation

Analogue explanation: Introducing the analogue concept related to the target concept in the analogy through at least one point.

Strategy identification: Emphasizing that the text presented as an analogy is an assimilation.

Both analogue explanation and strategy identification: Emphasizing both the explanation of the analogue and the strategy identification.

None: No emphasis on the analogue explanation or the strategy identification.

***8. The limitations of the analogy*:**

Noting the situation that there are breaking points in analogies in which misunderstandings are possible.

Results and discussions

In the new biology textbook that was examined in line with the purpose of this research many metaphors, anthropomorphic terms or expressions, and biomimetics to be interpreted as analogies were encountered. The following language was taken into account while deciding whether a comparison in the textbook was an analogy:

(1) Metaphors were not evaluated as analogies. Examples included: “Water is life” (p. 41); “Glucose is decomposed into smaller building stones by means of a serial enzyme” (p. 65); and “Forests are the lungs of our world” (p. 195).

(2) Anthropomorphic terms or expressions were not evaluated as analogies. Examples included: “…cells in our body are not capable of leaving the environment that they do not like” (p. 44); “…Archaebacteria are grouped as hot lovers, salt lovers and metal producers… the best temperature is 65–85 centigrade degrees for the archaebacteria which like hot environments” (p. 131); “Ants are examples of social groups. There are individuals with special duties such as “worker” and “soldier” ants within these groups” (p. 158); and “Organisms which are environment workers …” (p. 164).

(3) Biomimetics were not evaluated as analogies. For example: “The outer appearance or internal structure of living things contribute to the economy as models

in the production of many materials. Likewise, dragonflies were used in the construction of helicopters, polar bears were used in the construction of heat keeper clothes, spider webs were used in the construction of durable biological materials, and bats were used in the construction of radars" (p. 239).

(4) In some comparisons, analogue and target concepts were within the same domain of biology. Such comparisons were not evaluated as analogies. Examples included: "…vertebrates are another group that harmonize well with extraordinary living conditions like insects…" (p. 158); "…some of protists produce their own food like plants …" (p. 136); and "…latest molecular works show that mushrooms resemble animals rather than plants" (p. 140).

As it can be seen from the above examples, the origin of analogies and anthropomorphic expressions is metaphors. However, all metaphors are not analogies. Analogies and metaphors are close teaching tools in terms of meaning. For both analogies and metaphors describe interesting similes and comparisons. The difference between them is hidden in the process of comparison. In analogies, similar attributes of analogue and target concepts are brought to the forefront and an explicit comparison is made. In contrast, in metaphors interesting but nonconcurrent attributes of analogue and target fields are brought to the forefront and an implicit comparison is made. In fact, metaphors clearly have imitating or exaggerating expressions and they are mostly used in literary texts (Duit, 1991).

Based on the similarity condition of the target concept with the analogue, mainly two types of analogies are mentioned. They are same domain analogies and different domain analogies. As it can be seen in the above examples, analogue or target concepts in the same domain analogies are found in the same biological domain. Such analogies are not preferred so much because they can lead to misconceptions in students. In different domain analogies, on the other hand, analogue and target are found in different domains. In this research, the comparisons that are made between a biological target concept and an analogue concept from daily life were evaluated as analogies. For example, "a cell can resemble a pasta factory in terms of its structure and functions" (p. 94). Such analogies were based on the comparison between two different domains. The analogue domain was associated with daily life (pasta factory) and the target domain was associated with a biological concept (cell). Different domain analogies were evaluated as a pedagogic teaching tool in many research studies (Curtis and Reigeluth, 1984; Duit, 1991; Orgill and Bodner, 2006; Thiele et

al., 1995). Different domain analogies were emphasized to be effective in student understanding of unfamiliar target concepts.

A total of 25 analogies were found in the new biology textbook. Each analogy was examined independently by the researcher and two biology lecturers with an original agreement of 91.5% for the 183 classifications (8 criteria x 25 analogies). The remaining 17 classifications (8.5% of 200) were agreed upon following consensus discussions. Seventeen analogies on average were used in previous biology textbooks and 9.7 analogies on average were used in previous science textbooks in Turkey (Calik and Kaya, 2012; Dikmenli, 2010). Based on these results, it was determined that the use of analogies increased in the new biology textbook when compared to the biology textbooks that were prepared based on the previous curriculum. Curtis and Reigeluth (1984) determined that 8.3 analogies on average in science textbooks, Thiele and Treagust (1994) determined 9.3 analogies on average in secondary school chemistry textbooks, Thiele et al. (1995) determined 43.5 analogies on average in secondary school biology textbooks, Newton (2003) determined 2.6 analogies on average in science textbooks, and Orgill and Bodner (2006) determined 19.75 analogies on average in college biochemistry textbooks. This supports the results that more analogies are used in biology textbooks when compared to science and chemistry textbooks (Calik and Kaya 2012; Thiele et al., 1995).

Analogies were classified in four groups, namely macroscopic, microscopic, sub-microscopic, and symbolic in terms of the level of target concept. Biological concepts that can be directly observed or perceived by means of sense organs were evaluated within the macroscopic level; for example, organism and puzzle analogy (Figure 1).

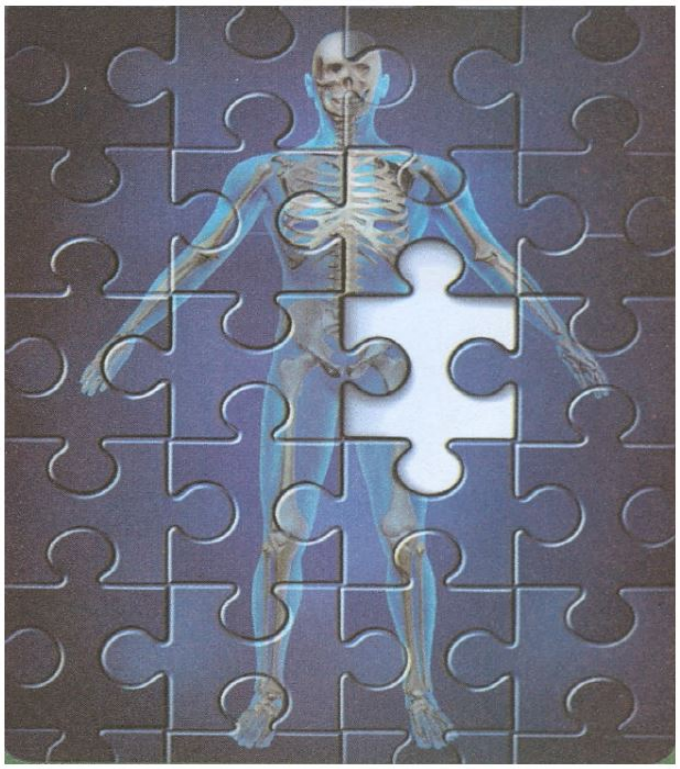

Figure 1. "Organisms are constituted by many parts which complete each other just like a puzzle…" (p. 38)

Biological concepts that can only be observed or perceived by means of microscopic tools were handled at the microscopic level. For example, "…in the electron microscope, there were hydrophobia viruses in the shape of a bullet inside the blood cells in the nerve tissue of an animal …" (p. 167).

Target concepts that cannot be directly observed like atoms and molecules but explained through models were at the sub-microscopic level. For example, "Enzyme molecules function just like the scissors and sewing machine of a tailor. That is to say, genes are cut by enzymes, and genes cut are tied by enzymes" (p. 67).

The target concepts that can be explained through biological formula or symbols such as genetic code were at the symbolic level. For example, "…if the information inside the DNA of a person was written in size 10 font on single line A4 paper, it would be like a 46 volume encyclopaedia each of which consists of nearly 23,000 pages" (p. 72).

In the new biology textbook, analogies were determined to be used for the target concepts mostly at the microscopic (28%) level and sub-microscopic level (28%), and then the macroscopic (24%) and symbolic (20%) level (Table 1). The microscopic and sub-microscopic nature of the target concepts such as viruses, bacteria, molecular structure of the cell membrane, enzyme molecule, DNA molecule, DNA fingerprint, and genetic information presented the role of the use of analogy in biology textbooks because these concepts can be either observed by means of microscopic tools or represented by means of instructional tools such as model and analogy, etc. In this regard, it was seen that most of the analogies in the biology textbook were used for biological concepts that are difficult to understand. Orgill and Bodner (2006) noted that analogies in college biochemistry textbooks were instead used for difficult target concepts such as energy, DNA and ATP. Dikmenli (2010), in contrast, showed that analogies in previous biology textbooks were generally used for biological concepts in relation to the structure and functions of the cell and nucleic acids. From this aspect, the findings of the present research promoted the results of previous studies. Chemistry consists of complicated and abstract matters. Therefore, chemistry teachers usually address concepts in three levels, namely microscopic, sub-microscopic, and symbolic (Johnstone, 1991; Treagust, Chittleborough and Mamiala, 2003). In this research, the microscopic level was added to these three levels by the very nature of biology because most of the biological concepts could only be observed by means of tools such as the light and electron microscope.

In terms of the analogical relationship between analogue and target concepts, it was determined that mostly functional (40%), and then structural-functional (32%) and structural (28%) analogies were found (Table 1). Most of the functional analogies were used for complicated and abstract biological concepts and they were interesting. In one of them, the function of the enzyme molecule was explained by comparing it to the function of scissors and a sewing machine (p. 67). In one of the structural-functional analogies, the cell concept was explained in details by comparing it to a pasta factory in terms of structure and function (p. 94). A structural analogy that was used in the textbook was formed by the following expressions. A “DNA molecule is made of a double nucleotide chain and it resembles tower stairs in terms of structure. The two edges of the stairs are made of phosphate and sugars, and the steps are made of bases” (p. 71). While functional analogies were higher in number in the new biology textbook in terms of the analogical relationship between the analogue and target concepts, structural analogies were higher in number in

previous biology textbooks (Dikmenli, 2010). When we suppose that functional or structural-functional analogies are more effective in teaching (Duit, 1991; Thiele and Treagust, 1994), it is desired to use functional analogies mostly in the new biology textbook. In a structural analogy, students should be aware that analogue and target concepts only share structural attributes. Otherwise, students can also transfer function and behaviour attributes from the analogue to the target. In such a case, students can develop misconceptions (Orgill and Bodner, 2006). According to previous research, functional analogies were used mostly in science, chemistry, biology, and biochemistry textbooks (Curtis and Reigeluth, 1984; Thiele and Treagust, 1994; Thiele et al., 1995; Orgill and Bodner, 2006).

In terms of presentation format, it was determined that 19 analogies in the book (76%) were presented in the verbal format while six analogies (24%) were presented in the pictorial-verbal format (Table 1). In one of the analogies that were presented in the pictorial-verbal format, cell concept was explained by comparing it to a pasta factory (p. 94). In this analogy, which is structured in detail, the cell membrane resembled a factory wall, the pores in the cell membrane to security officers, cytoplasm to a factory garden, ribosome to production machinery, Golgi apparatus to the packaging unit of the factory, mitochondria to an energy plant, and core to the management centre of the factory. This analogy in the book was promoted through images of the analogue and target (Figure 2, p. 94).

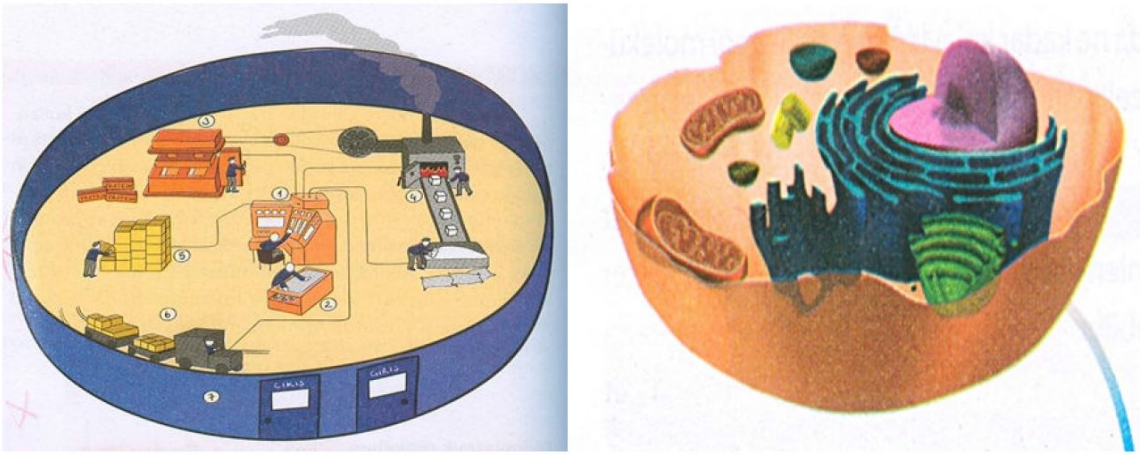

Figure 2. An example of Pictorial-verbal analogy used in the new biology textbook (p. 94).

In this analogy, written text was promoted through an image of the analogue and thus the cell topic became an interesting and permanent one for the students. In most of

the verbal analogies that were used in the textbooks, analogical expressions were promoted through microscopic and sub-microscopic images and diagrams of the target concept. Dikmenli (2010) determined that pictorial-verbal analogies were used much less (42%) in previous biology textbooks. The spread of pictorial-verbal analogies in the new biology textbook was a positive development for students because pictorial-verbal analogies facilitate remembering and increase the permanency of knowledge. It is known that images are remembered more than sentences. Bean, Searles, Singer and Cowen (1990) concluded that an analogy that is presented in pictorial-verbal format was more effective in understanding the structure and functions of the cell when compared to an analogy which is presented in verbal format.

Table 1. Categorization and number of analogies in the ninth grade biology textbook.

Category	Number of Analogies	25	%
Level of Target Concept	Macroscopic	6	24
	Microscopic	7	28
	Sub-Microscopic	7	28
	Symbolic	5	20
Analogical Relationship	Structural	7	28
	Functional	10	40
	Structural-Functional	8	32
Presentation Format	Verbal	19	76
	Pictorial-Verbal	6	24
The level of abstraction	Concrete-Concrete	4	16
	Abstract-Abstract	2	8
	Concrete-Abstract	19	76
Position	Advance Organizer	6	24
	Embedded Activator	17	68
	Post-Synthesizer	2	8
Level of Enrichment	Simple	13	52

	Enriched	7	28
	Extended	5	20
Pre-topic Orientation	Analogue Explanation	3	12
	Strategy Identification	1	4
	Both	4	16
	None	17	68
Limitations	Existing	4	16
	None	21	84

In terms of the level of abstraction of the analogue and target concepts, it was found that 16% of the analogies in the biology textbook were concrete-concrete, 8% were abstract-abstract and 76% were concrete-abstract (Table 1). The most significant role of the analogies was to concretize the abstract concepts. Students cannot directly observe abstract concepts in the classroom environment but they can envisage them thanks to instructional tools such as model and analogy. It was determined that mostly concrete-abstract analogies were used in the biology textbook. For example, “Cell resembles a small chemistry factory…thousands of reactions occur per second in this factory…” (p. 63). In this analogy, the biological events that occur in a cell were explained by comparing them to the events that occur in a small chemistry factory. Previous research also presented similar results (Dikmenli, 2010; Orgill and Bodner, 2006; Thiele et al., 1995). Unlike these research studies, Newton (2003) claimed that concrete-concrete type analogies were used more frequently in elementary school science textbooks that were prepared for students in the age group of 7–11. In elementary education, the students in younger classes are at the phase of concrete processes based on their cognitive development phases. These students could not understand abstract concepts and their relations well. These students cannot perceive abstract relations in analogies, either. Therefore, the analogies, which are established in these classrooms, had to be at a superficial and concrete level.

In terms of the position of the analogue relevant to the target, mostly embedded activator (68%), and then advance organizer (24%) and post-synthesiser (8%) type analogies were used in the new biology textbook (Table 1). Previous studies also presented similar results (Dikmenli, 2010; Curtis and Reigeluth, 1984; Orgill and

Bodner, 2006; Thiele and Treagust, 1994). Specifically, Newton (2003) determined that all analogies in science textbooks that were prepared for students at the age group of 7–11 were embedded activator. The analogies in the embedded activator type were more convenient for students in the younger age group because advance organizer or post-synthesiser type analogies required experience and preliminary knowledge for students.

In terms of the level of enrichment of analogy, mostly simple (52%), and then enriched (28%) and extended (20%) analogies were used in the biology textbook (Table 1). Simple analogies were commonly used in both current and previous biology textbooks (Dikmenli, 2010). However, research studies noted some disadvantages of simple analogies. In simple analogies, the students had to establish the relationship between the analogue and target domain themselves. Therefore, frequent use of simple analogies could lead students to develop misconceptions (Thiele et al., 1995). Glynn and Takahaski (1998) claim that analogies should be enriched or extended as suitable for the purpose. Elaborate analogies facilitated students learning the target concept and increased their interest in the topic (Paris and Glynn, 2004).

In terms of pre-topic orientation, 12% of the analogies used in the biology textbook only involved analogue explanation, 4% only involved strategy identification, while 16% involved both analogue explanation and strategy identification. Sixty-eight per cent of the analogies involved neither analogue explanation nor strategy identification (Table 1). Approximately similar results were seen in elementary and middle school science, chemistry, and biology textbooks (Curtis and Reigeluth, 1984; Dikmenli, 2010; Thiele and Treagust, 1994). In order to establish a correct analogical transfer between the analogue and target field, the basic attributes of the analogue that is used in the analogy should be explained. Curtis ve Reigeluth (1984) claims that analogue explanation is highly significant when the analogue is unknown, complicated or unfamiliar for the learner. Analogue explanation aims to guarantee that the students focus on suitable qualifications in the analogical transfer (Thiele and Treagust, 1994). Furthermore, students should be aware of the fact that the comparison made between the analogue and target field is an analogy (strategy identification). Otherwise, the reader can transfer unwanted relationships and this can lead to misconceptions. Although there are similar aspects between the analogue and target fields in an analogy, students should be shown that these similarities never

completely overlap with each other. In case of failure to do this, the analogue concept could sometimes replace the target concept.

In terms of the limitations of analogy, limitations were emphasized in 16% of the analogies that were used in the biology textbook, and the limitations of analogies were not pointed out in 84% of them (Table 1). An example that marked the limitations of analogy was as follows: “Cell resembles a small chemistry factory…thousands of reactions occur per second in this factory…. It should be known that a cell is not a place where thousands of enzymes work randomly. The reactions in the cell occur in order. And, the intracellular environment is a different laboratory where different events occur…” (p. 63). Approximately similar rates were also seen in chemistry and biology textbooks (Dikmenli, 2010; Thiele and Treagust, 1994). In order to prevent misconceptions that can originate from analogies (Brown and Clement, 1989; Clement, 1993; Coll and Treagust, 2001; Kao, 2007), it was necessary to mention the breaking points, which might lead to misconceptions in the analogies used in the textbooks or the attributes that are not shared between the analogue and target.

Conclusion and suggestions

This research revealed that a great number of analogies, metaphors, biomimetics, and anthropomorphic terms were used in the ninth grade biology textbook. It was determined that the analogies in the new biology textbook were used more frequently when compared to previous biology textbooks. In terms of the level of the target concept, more than half of the analogies were at the microscopic and sub-microscopic level. These target concepts usually contained molecules such as DNA, enzymes, and cholesterol. And this was a positive development when compared to previous biology textbooks.

It was found that there were functional, verbal, concrete-abstract, embedded activator, and simple type analogies in the new biology textbook. Most of the analogies in the textbook did not mention the limitations of the analogy. In order to prevent misconceptions originating from the analogies for students, it was necessary to mention the unsuitable aspects of the analogue in the target in an analogy. Some of the simple analogies were found to be superficial for students and unsuitable for analogy-based teaching. Therefore, importance should be given to enriched and extended analogies instead of featuring simple analogies in textbooks. The analogies

in the textbooks should be explained and detailed in a comprehensible manner as suitable for the purpose.

The cognitive development levels and individual attributes of students should be taken into consideration while preparing analogies for textbooks. Sometimes, students can misunderstand the analogies in the textbook due to their individual attributes or cognitive levels. The author determines the kind, scope, and presentational format of the analogies in the textbook. The author aims to introduce new or unknown target concepts for the learner while creating the analogy. This aim can be interrupted due to the presentation format of the analogy or the individual differences in the learning process. Therefore, significant duties are placed on the teachers who use the textbooks as a teaching material. Teachers should filter the analogies in the textbooks and revise them in a way that is comprehensible to the student whenever necessary. Secondary school biology curricula should contain explanations and suggestions about instructional analogies for the textbook authors.

For analogies to become effective teaching tools in biology textbooks, they should be created relying on guides such as Teaching with Analogies (TWA; Glynn, 1991) and Focus-Action-Reflection (FAR; Treagust et al., 1998), and their limitations should be explicitly described and systematically presented.

A separate study can be done for metaphors and anthropomorphic expressions in the biology textbook that was examined in this research. It is suggested that the views of teachers and students on the analogies used in biology textbooks can be studied.

References

Bean, T.W., Searles, D., Singer, H. & Cowen, S. (1990). Learning concepts from biology text through pictorial analogies and an analogical study guide. *The Journal of Educational Research*, *83*(4), 233-237.

Brown, D.E. & Clement, J. (1989). Overcoming misconceptions via analogical reasoning: Abstract transfer versus explanatory model construction. *Instructional Science*,*18*(4), 237-261.

Chiappetta, E.L., Ganesh, T.G., Lee. Y.H. & Phillips, M.C. (2006). Examination of science textbook analysis research conducted on textbooks published over the past 100 years in the United States. *Paper presented at the annual meeting of the National Association for Research in Science Teaching*, San Francisco, CA.

Calik, M. & Kaya, E. (2012). Fen ve teknoloji ders kitaplarinda ve ogretim programindaki benzetmelerin incelenmesi. *Ilkögretim Online*, *11*(4), 856-868.

Clement, J. (1993). Using bridging analogies and anchoring intuitions to deal with students' preconceptions in physics. *Journal of Research in Science Teaching, 30*(10), 241-1257.

Coll, R.K. & Treagust, D.F. (2001). Learners' use of analogy and alternative conceptions for chemical bonding: a cross-age study. *Australian Science Teachers' Journal*,*48*(1), 24-32.

Curtis, R.V. & Reigeluth, C.M. (1984). The use of analogies in written text. *Instructional Science*, *13*(2), 99-117.

Dikmenli, M. (2010). An analysis of analogies used in secondary biology textbooks: case of Turkey. *Eurasian Journal of Educational Research*, *41*, 73-90.

Duit, R. (1991). On the role of analogies and metaphors in learning science. *Science Education*, *75*(6), 649-672.

Duit, R., Roth, W-M., Komorek, M. & Wilbers, J. (2001). Fostering conceptual change by analogies – between Scylla and Charybdis. *Learning & Instruction*, *11*(4), 283-303.

Dunbar, K. (2001). The analogical paradox: Why analogy is so easy in naturalistic settings, yet so difficult in psychological laboratory. In D. Gentner, K.J. Holyoak, B.N. Kokinov (Eds.), *The analogical mind: Perspectives from cognitive science* (pp 313-334). Cambridge, M.A: MIT press.

Gilbert, S.W. (1989). An evaluation of the use of analogy, simile, and metaphor in science texts. *Journal of Research in Science Teaching*, *26*(4), 315-327.

Glynn, S.M. (1991). Explaining science concepts: A teaching-with-analogies model. In S.M. Glynn, R.H. Yeany, B.K. Britton (Eds.), *The psychology of learning science*(pp. 219-240). Hillsdale, NJ: Erlbaum.

Glynn, S.M. & Takahashi, T. (1998). Learning from analogy-enhanced science text. *Journal of Research in Science Teaching*, *35*(10), 1129-1149.

Heywood, D. (2002). The place of analogies in science education. *Cambridge Journal of Education*, *32*(2), 233-247.

Johnstone, A.H. (1991). Why is science difficult to learn? Things are seldom what they seem. *Journal of Computer Assisted Learning*, *7*, 75-83.

Kao, H-L. (2007). A Study of aboriginal and urban junior high school students' alternative conceptions on the definition of respiration. *International Journal of Science Education*, *29*(4), 517-533.

Komisyon (2014). *Ortaöğretim Biyoloji 9*. Birinci Baskı, Özyurt Matbaacılık, Ankara.

Mclachlan, J.C. (2003). Using models to enhance the intellectual content of learning in developmental biology. *International Journal of Developmental Biology*, *47*(2), 225-229.

Newton, L.D. (2003). The occurence of analogies in elementary school science books. *Instructional Science*, *31*(6), 353-375.

Orgill, M-K. & Bodner, G. (2004). What research tells us about using analogies to teach chemistry. *Chemistry Education Research and Practice*, *5*(1), 15-32.

Orgill, M-K. & Bodner, G. (2006). An analysis of the effectiveness of analogy use in college-level biochemistry textbooks. *Journal of Research in Science Teaching*, *43*(10), 1040-1060.

Parida, B.K. & Goswami, G. (2000). Using analogy as a tool in science education. *School Science: Quarterly Journal of Science Education*, *38*, 4. (Downloaded on 15 February, 2007). (http://ncert.nic.in/sites/publication/sschap10.htm).

Paris, N.A., Glynn, S.M. (2004). Elaborate analogies in science text: Tools for enhancing pre-service teachers' knowledge and attitudes. *Contemporary Educational Psychology*, *29*(3), 230-247.

Stavy, R. (1991). Using analogies to overcome misconceptions about conservation of matter. *Journal of Research in Science Teaching*, *28*(4), 305-313.

Thiele, R.B. & Treagust, D.F. (1994). The nature and extend of analogies in secondary chemistry textbooks. *Instructional Science*, *22*(1), 61-74.

Thiele, R.B., Venville, G.J. & Treagust, D.F. (1995). A comparative analysis of analogies in secondary biology and chemistry textbooks used in Australian schools.*Research in Science Education*, *25*(2), 221-230.

Treagust, D.F., Harrison, A.G. & Venville, G.J. (1998). Teaching science effectively with analogies: An approach for preservice and inservice teacher education. *Journal of Science Teacher Education*, *9*(2), 85-101.

Treagust, D.F., Chittleborough, G. & Mamiala, T.L. (2003). The role of submicroscopic and symbolic representations in chemical explanations. *International Journal of Science Education*, *25*(11), 1353-1368.

Venville, G.J. & Treagust, D.F. (1996). The role of analogies in promoting conceptual change in biology. *Instructional Science*, *24*(4), 295-320.

Venville, G.J. & Treagust, D.F. (1997). Analogies in biology education: A contentious issue. *The American Biology Teacher*, *59*(5), 282-287.

Yildirim, A. & Simsek, H. (2005). *Sosyal bilimlerde nitel arastirma yontemleri*. (5. Baski), Seckin Yayincilik, Ankara.

Zeitoun, H.H. (1984). Teaching scientific analogies: A proposed model. *Research in Science and Technological Education*, *2*(2), 107-125.