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Research Trends about Analogy Studies in Science Education: A Descriptive Content Analysis

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ABSTRACT Analogies are bridges between prior knowledge and new knowledge to make meaning of the new one. Analogies are particularly effective in teaching science concepts that are not very apparent in the students' everyday lives due to their abstract nature. For this reason, it is essential to adapt analogies to teach new concepts effectively in science education. Analogy-related studies published between 2009 and 2020 were examined in this manuscript to determine the use of analogies as a teaching technique in science education (Physics, Chemistry, Biology). To reach the studies about "Analogy," ERIC, EBSCO, Springer LINK, Taylor & Francis, Wiley Online Library Full Collection, Science Direct, ProQuest Dissertations, Theses Global, Google Scholar, and Scopus databases were searched. Then, Turkish databases, including ULAKBIM and YÖK (National Thesis Center), were also searched. A total of 80 research papers published between 2009 and 2020 that met the study's criteria were examined. Within the scope of the study, the subject areas, purpose, sample, results, and suggestions of compiled analogy studies were focused on. Based on the analysis, it was determined that most of the analogy research was conducted in the field of chemistry, the most employed methodology was qualitative research, and the most common purpose of these studies was to see the effects on academic achievement. When the studies were conducted to examine academic achievement, it was seen that the use of analogy applications as a teaching technique in science teaching has positive results on student achievement.

Keywords Science education, Physics, Chemistry, Biology, Analogy, Descriptive content analysis

1. INTRODUCTION

Individuals' curiosity and desire to explore lead them to inquiry and research, resulting in a gradual increase in the knowledge of more efficient teaching. The main purpose of science education studies is to improve the teaching and learning of science. For this reason, appropriate teaching strategies, methods, and techniques should be developed and applied to enhance students' conceptual understanding of science. In science courses, it is often encountered that students do not have the level of knowledge to explain a scientific concept and/or phenomenon. At this point, analogies are one of the techniques frequently used in the teaching process related to science (Dagher, 1995; Thiele & Treagust, 1994). As a teaching technique, an analogy can bridge the gap between prior knowledge, concept, or phenomenon and the new one (Podolefsky & Finkelstein, 2006). Educators often use metaphors to understand further, embody abstract concepts, and provide permanent learning (Akaygun, Brown, Karataş, Supasorn, Yseen, 2018). An analogy relates an unfamiliar formula, process, or concept to a more familiar one to the individual based on previous experiences. Thus, new knowledge is created mentally by establishing connections between the individual's existing and new schemata. Analogies help students visualize concepts and facilitate knowledge construction in their minds, and play an important role in identifying misconceptions (Dinçer, 2011; Gentner, 1983).

The analogy can be mapped symbolically as follows. B → T, B is the base field i.e. the source (for example, the solar system), T is the target, that is, the domain where new concept/knowledge is generated (for example, an atom) (Podolefsky & Finkelstein, 2006).

It is well documented that students do not have sufficient amount of knowledge to explain concepts and phenomena in science (Çetingül, Geban, 2011; Çıldır, 2009). At this point, it is stated in various studies that analogies are one of the most effective techniques in the teaching and learning process for comprehension and retention (Kesercioğlu, Yılmaz, Cavaş & Cavaş, 2004). At the same time, it can be said that the analogies increase

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students' motivation to learn by considering the concepts from the other points of view. (Dinçer, 2005; Akaygun, Brown, Karatas, Supasorn, Yseen, 2018). For this reason, the use of analogies in science education facilitates the construction of new concepts that are difficult to understand due to their abstract and particulate nature and processes. Furthermore, it is known that science education deals with teaching many abstract concepts found in nature compared to other disciplines. In this context, it can be said that the use of analogies in teaching concepts that are difficult to understand will make an important contribution to the teaching process by facilitating learning (Dagher & Cossman, 1992). Analogies, an effective technique in learning and teaching, make learning meaningful and increase retention of the concepts that are difficult to understand by students. Therefore, the main reason to carry out this study is to determine how educators use analogies in science education.

Considering the effects of analogy on science education, determining what products and consequences it has on students and educational processes are an important part of the literature. When topics and concepts that are hard to understand are learned easily and meaningfully by using the analogy technique, it is necessary to reveal the current trends related to research about analogies in science education. In addition, a thematic content analysis study would shed light on the deficiencies of using the analogy technique and reveal how to use the analogy technique effectively. Therefore, in line with the studies reviewed in this research, the quality and quantity of research subjects related to "analogy" are evaluated in terms of method and technique. Accordingly, the main trends in the field are tried to be determined. At this point, it is believed that conducting a thematic analysis that includes the topic, purpose, methodology, conclusions, and implications about "using analogies in science education" would help and guide researchers and teachers. It is also believed that the study would significantly contribute to the field by showing current trends and possible new directions. In this context, "What are the trends in research on analogies used as a teaching technique in science education?" is the main research question that an answer is sought. Within the framework of the main research question and in line with the sub-questions given below, the studies in the relevant literature were evaluated:

1. What is the distribution of the analogy studies by their subject and publication years?
2. Who were the participants of the analogy studies?
3. What data collection techniques and tools were used in the studies?
4. What are the purposes and associated methodologies of the studies to be conducted?
5. What is the effectiveness of analogies in line with the main results of the studies?

Recent changes in science curricula all over the world have emphasized interdisciplinarity and conceptual understanding by students rather than subject specificity and calculation for mathematical equations regarding scientific laws and theories has increased the use of analogies in the teaching process (Çetingül & Geban, 2011; Harman & Çökelez, 2017; Köklü, 2009). At this point, an answer was sought to the question of the trends of studies about the analogy in science education between the years 2009 and 2020. In this way, teachers who use or will use analogies in science education can find how to use analogies effectively. Similarly, researchers might find what issues emerged and should be further investigated. With these kinds of studies, it is desired to avoid repetition and disorganization of educational research by understanding where studies are focused on and what aspects of the phenomena should be investigated further (Çalık & Sözbilir, 2014). In this way, teachers and researchers interested in the developments in educational research would be informed. It also plays an essential role in solving the problems arising from the use of analogies.

2. METHOD

Descriptive content analysis, one of the content analysis methods, was used to direct the study. Studies carried out in a field should be synthesized according to various parameters or criteria to evaluate the research results and provide clear recommendations for future research by organizing and sorting them. Thus, it can be revealed where studies on the same subject support or contradict each other. While conducting similar studies can be avoided by descriptive content analysis research, it may also lead to new studies that take different perspectives into account. (Au, 2007; Çalık & Sözbilir, 2014). In this study, articles and theses in science education involving analogy techniques were analyzed using a descriptive content analysis research design, and they were gathered with a holistic approach. Although analogies are used in different fields (e.g., social studies, literacy, mathematics), they take place more intensely in science education due to the nature of science. Therefore, investigating current trends about analogies in science education is more fruitful. Within the scope of this study, 80 studies published between 2009-and 2020 that met the research criteria were examined. Considering the analogy studies in science education published between 2009-and 2020 is considered a limitation of the study. Examining only thesis and journal articles would be another limitation.

2.1 Instruments

In this study, several databases were searched to reach and examine "Analogy" studies in science education. First of all, to reach the studies published between 2009 and 2020 about "Analogy" ERIC (EBSCO), Springer LINK, Taylor & Francis, Wiley Online Library Full Collection, Science Direct, ProQuest Dissertations, and Theses

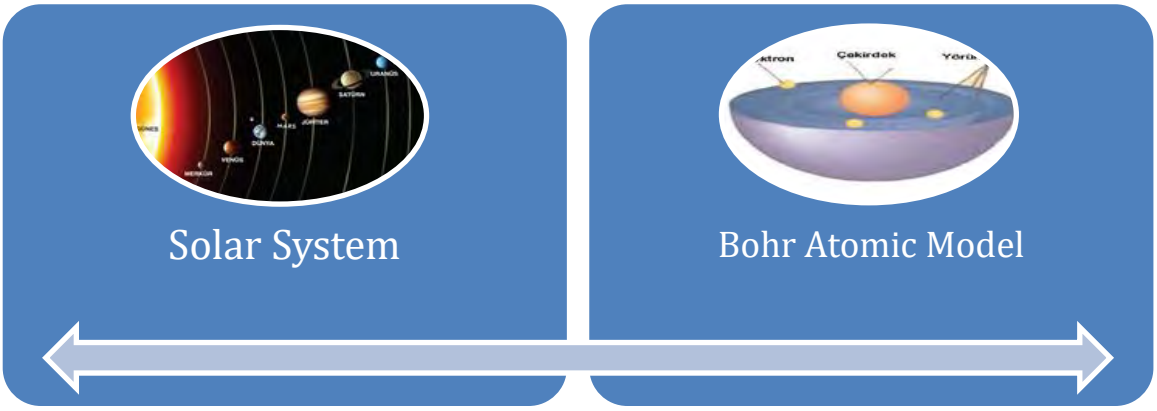

Image 1 Solar system

Image 2 Bohr's Atomic Model

Figure 1 An example of a visual analogy for an explanation of the Bohr atomic model by using the solar system

Global, Google Scholar, and Scopus databases were searched. Then, Turkish databases, including ULAKBIM (National Database) and YÖK (National Thesis Center). The following keywords or combinations of them have entered the database engines: "analogy," "analogy teaching," "analog reasoning," "science education," "chemistry education," "chemistry teaching," "physics teaching," and "biology teaching."

The inclusion criteria for the publications were as follows: (a) manuscripts from peer-reviewed journals; (b) having a complete text; (c) thesis and dissertations (d) primary research – not descriptive content analysis. Although studies related to metaphor are not included, studies in which analogy and metaphor are used together have also been considered. A total of 97 articles were reached from the databases, but after the elimination process and in the case of duplicates, 80 studies were included for descriptive content analysis.

2.2 Data Analysis

A total of 80 studies obtained from the databases identified in the study were subjected to the content analysis (Ültay & Çalık, 2012; Yıldırım, Kurşun & Göktaş, 2015). The themes determined for the research analysis are subject, aim, sample, method, data collection tools, data analysis, result, and suggestion, respectively.

2.3 Validity and Reliability

The selected studies were carefully examined to avoid any data loss, and analysis was performed on the specified parameters. In order to prevent errors in the analysis, the studies were examined by sorting them into themes. The repeated studies on the same theme are shown with the frequency and percentage values of each sub-category. In addition, after the categories and themes were created, a verification process was employed by cross-checking the findings, the themes, the categories, and the researcher's rationale for sorting the study into a certain category. The category and theme creation process was reviewed by another researcher who is an expert in content analysis to increase the validity of the analysis.

3. RESULT AND DISCUSSION

Findings

The analysis of the studies was organized based on specific aspects of the study, including subject, publication year, target groups, purpose, methodology, data collection techniques, findings, and suggestions.

The publication years of the studies were sorted by field of science and demonstrated in Figure 1. As seen in Figure 1, the years in which the highest number of publications were recorded are 2012/2016/2019 in general science (3), 2009/2012 (5) in physics, 2013 (7) in chemistry, and 2012/2015 (3) in biology. In the general distribution of analogy studies between 2009 and 2020, the most published research items were observed in 2012 (13). Most of the studies were conducted in the field of chemistry education (30), followed by the field of physics education (21), science education in general (16), and biology education (13), respectively.

When the methodology of the studies was examined, there was a clear trend of change over the years, but the qualitative research method (41) was mainly employed, as shown in Figures 2 and 3. Quantitative research (31) and

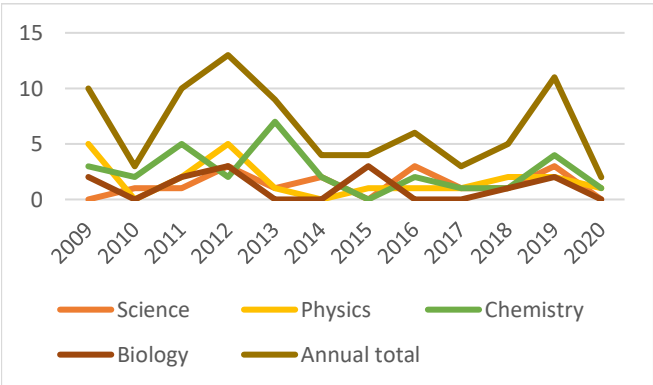

Figure 2 Distribution of studies using analogy technique according to years and subjects

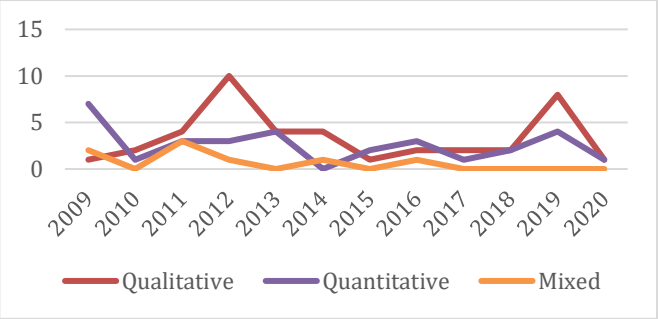

Figure 3 Distribution of research methods approaches by year of studies using analogy technique

mixed research methods (8) were the second and third most used methodologies, respectively. The studies conducted with a qualitative approach were the highest in 2012. 2009 and 2011 are the highest number of studies undertaken in quantitative and mixed methods approaches, respectively.

As seen in Table 1, the distribution of target groups of the analogy studies is primarily students and teachers. Many studies focused on textbooks and analogies used in these textbooks. Notably, high school students are the most studies conducted with (21) following target group is elementary students (21). The most preferred third sample type is pre-service teachers (15). Even though 80 studies on analogy conducted between 2009 and 2020 were examined, the total number of sample types is more than 80 as some studies focused on more than one sample type. It is seen that the most documented studies are from science textbooks (8). Notably, analogies in physics textbooks are the least studied.

In Table 2, the distributions of data collection tools of the studies are shown in frequency and percentage. It is seen that achievement/knowledge/concept tests (42) are the most used data collection tools in analogy studies. It is followed by interviews (22) and then documents (17). The least used data collection tools are the analogical/logical thinking ability test.

In Table 3, the distribution of the aims and research methods of the studies using the analogy technique. It is seen that studies using analogies are mainly conducted using qualitative methods (52) and followed by quantitative research methods (34). Remarkably, the mixed method (13) is the least used methodology. The aims of the study show that the qualitative research methods are mostly used to determine the analogy profile (11). Among the quantitative study methods, it is seen that academic achievement (17) is the study's main purpose. In the mixed method, which is seen to be used much less than the qualitative and quantitative methods, it is seen that the research objectives are mostly to determine the effect of analogies on academic achievement (4).

Table 4 shows the findings regarding the effectiveness of the results of the studies in which the analogy technique

Table 1 Distribution of studies using analogy technique according to sampling type

Sample		f	%
Participant	High school students	21	26
	Elementary students	21	26
	Pre-service teachers	15	19
	Teachers	6	8
	Pre-school students	1	1
	Faculty	1	1
Total		65	
Document	Science textbooks	8	10
	Chemistry textbooks	5	6
	Biology textbooks	3	4
	Physics textbooks	1	1
Total		17	

Table 2 Distribution of data collection tools of studies using analogy technique

Data collection tools	f	%
Achievement / Knowledge / Concept test	42	53
Interview	22	28
Document	17	21
Scale	16	20
Survey	10	13
Work Sheets	13	16
Misconception test	8	10
Observation	6	8
Analogical / Logical thinking ability test	5	6

was used. The results of the studies were sorted under the categories of positive, negative, various variables, and document analysis. It has been found that the majority of the studies have reported positive results that analogies increase the academic achievement, comprehension, motivation, etc., of the students. However, eleven studies pointed out that teachers are partially competent in producing original analogies. As shown in Table 4, the scientific processing skills of the students make a significant difference in the analogy technique. Document analysis concluded that analogies were not used sufficiently in the textbooks, their limitations were not specified, and they were simple and limited in number.

Suggestions that emerged from the studies are essential and may shed light on future research and teaching. The suggestions were sorted into four categories: future research, teacher training, material/activity development, and classroom practice, as seen in Table 5. Almost one-third of the studies placed research suggestions. The majority of them recommended that future research focus on investigating the effects of types of analogies on different age groups and subjects. Another group of suggestions emphasized teaching and learning with analogies. The quality and quantity of analogies used in

Table 3 Distribution of studies using analogy technique according to their objectives and research methods

Method	Research purpose	f	%
Qualitative	Identifying an analogy profile	11	14
	Document (textbooks) review	10	13
	The competencies of teachers/students to create analogies	9	11
	Examining instructional analogies	5	6
	Misconceptions	5	6
	Examining the designs in which the analogy technique is integrated	4	5
	Academic achievement	3	4
Total		52	
Quantitative	Academic achievement	17	21
	Attitude	8	10
	Permanence/retention	4	5
	Various variables	3	4
	The effect of analogies on creative thinking	2	3
Total		34	
Mixed	Academic achievement	4	5
	Attitude	3	4
	Permanence/retention	2	3
	Conceptual change	2	3
	The effect of the analogy technique on the applied model	2	3
Total		13	

** Some of the studies may have more than one purpose.*

Table 4 The effectiveness of analogy according to the main findings of the studies

Research results		f	%
Positive Results	Achievement	21	26
	Conceptual understanding	14	18
	Less alternative conceptions	12	15
	Positive impact on scientific creativity	10	13
	Attention and motivation	8	10
	Linking everyday life and science	8	10
	Permanent learning	7	9
	Positive attitudes towards analogies	5	6
	Positive opinions about analogies	3	4
Negative Results	Incompetent teachers	11	14
	Ineffective in academic achievement	4	5
	Ineffective in attitude	3	4
Results according to various variables	No difference by gender	2	3
	The higher science processing skills, the more effective analogy learning	2	3
	That attitudes differ by gender	2	3
Document results	Not specifying the limitations of the analogy	7	9
	Not used sufficiently in textbooks	6	8
	Simple analogies	5	6
	Using abstract concepts	2	3

textbooks should be improved, and more comprehensive analogies should be used in classrooms were other notable suggestions.

The main aim of this study is to find current research trends about analogies in science education. The results from the analysis within the framework of identified criteria will be discussed to fulfill this aim. The findings show that although analogy studies do not follow a dist inct course, they were carried out more intensively in the early years of the search span. Therefore, the analogy studies have lost their popularity along the way. On the other hand, it is observed that analogy studies are carried out less in biology than in other fields and that most studies are carried out in the field of chemistry. The fact that there are fewer abstract

Table 5 Suggestions of the selected studies

Research suggestions		f	%
Future research	The effect of analogy types according to age groups and lessons	13	16
	Application with different learning models	8	10
	Studies should be carried out on the suitability of students to their cognitive levels.	6	8
	Creating workspaces	5	6
Teacher education	In-service teacher training for analogies	6	8
	Analogies should be integrated into the pre-service course content	5	6
	Encouraging teachers to use models	3	4
For material/activity development	Comprehensive analogies should be used	5	6
	Analogies that create alternative activities should be prepared by organizations or centers	5	6
	Analogies should be used with their limitations	4	5
	Innovative techniques and models should be applied	4	5
	Information about analogy should be included in textbooks	2	3
For in-class applications	More analogies should be used in teaching	13	16
	Designing the courses based on learning styles	4	5

subjects in biology than in other fields would be the reason (Lawson, 2001; Marcelos & Nagem, 2012). Analogy studies conducted in the field of biology are among the subjects of "Cell and Structure" and "Systems in our body", where abstract concepts are most difficult for students, and analogy examples are more common in teaching (Digilli, 2014). There is a lot of work in chemistry that suggests that the use of analogy may be more effective in chemistry that contains a lot of abstract topics and concepts. Another supportive finding is that analogies are used more often at younger ages, and abstract thinking has not been developed well. Thus, Şahin (2016) claimed that analogies are more effective with young age groups and with individuals whose cognitive development has not been completed yet. At the same time, it can be said that abstract concepts should be associated with concrete concepts at an early age to make the analogy technique more fruitful in science (Arıcı, 2018). However, Kılıç (2009) suggested that primary school students had difficulties generating analogies because they did not enter the abstract processing period. Therefore, it may be more beneficial not to ask students to develop their analogies. But instead, teachers should bring the class a well-articulated analogy for the related topic.

According to the findings obtained from the study; studies using analogy technique are frequently reported to be carried out with high school students (Ketenci, 2019; Kobal, 2011), elementary school students (Taşkara, 2015; Ünlü & Dökme, 2011), and then with pre-service teachers (Haglund & Jeppsson, 2012; Kurt, 2019; Türk, Ayas & Karslı, 2010). It is believed that the studies conducted with students in this age range are due to the cognitive difficulties in understanding abstract concepts contained in a science curriculum. However, the result that 7th-grade students benefit more from the analogies obtained in Mason & Tornatora (2016) study does not support this situation. After that, the primary reasons for choosing to work with the pre-service teacher would be either convenience that the researchers can easily reach them or due to the previous research about teacher competencies. Either way, pre-service teacher training has a certain focus on analogy research. It is noteworthy that the studies that examined textbooks focused on middle school the most and high school physics textbooks the least. It would be considered a contradiction to the previous comment; however, it also supports that younger-age students can learn easily with analogies.

When we look at the data collection tools used in the analogies studies, achievement and concept tests (Çalık, Ayas & Ebenezer, 2009; Çoban, 2019) and interviews are used more often than the others (Ashe & Yaron, 2013; Çalık & Kaya, 2012; Haglund, 2013; Harman & Çökelez, 2017). That resembles other typical research conducted in science education, in which achievement tests, scales, and interviews are the most frequently used data collection tools. In addition, it was revealed that studies using a mixed-method approach were less common, and using multiple data sources was not common practice either. These might be the studies carried out by small teams or even by individuals.

When we look at the aims and research methods of the examined studies, it is seen that most of the qualitative research includes document analysis of the textbooks. On the other hand, the quantitative studies utilized experimental design to test the effects of analogies on achievement. Findings indicate that mixed-method research is less usual than the studies using qualitative or quantitative methods. These studies were mainly conducted to determine the misconceptions and analogy competencies of the participants (Aykutlu & Şen, 2012; Muştu & Özkan, 2017) has been carried out. Similarly, the

cognitive characteristics of the participants are tried to be determined in these studies. Although these studies are very important in the literature, they generally show that situation determination cannot proceed further. In addition, it is thought that the subjects and participants should be diversified by integrating the analogy technique into the teaching environments to reveal the participants' conceptual knowledge, understanding, or models. In addition, Cain (2016) argued that instructional analogies do not significantly differ in science achievement between high and low academic ability students in line with the data obtained in her study. This study shows that the analogies that benefit the classroom do not agree with the literature in their actual use. Therefore, it can be said that these studies also provide a better understanding of how analogies are developed or should be shaped in future research. Although studies have been conducted on the effectiveness of different methods of constructivism, such as project-based learning (Çıbık & Yalçın, 2012), it is noticeable that the number of studies about the effect of an analogy and a model on conceptual change is very limited. In this context, it can be inferred that studies on analogy remain at a more general level rather than in-depth investigations.

The studies reviewed usually reported that analogies improve the academic achievement of the students (Arıcı, 2018; Çoban, 2019; Zorluoğlu & Sözbilir, 2016). Research also suggests that pictorial representations can help students develop better performance in analogical reasoning and problem-solving skills (Lin, Shiau & Laawrenz, 1996). With the right instructional design, teaching activities involving analogy can lead to logical thinking and encourage creative thinking. These results are supported by studies in which successful organization and integration of knowledge into learning/teaching materials can improve students' learning outcomes (Mason, Tornatora & Pluchino, 2013). But, some of the reviewed studies have shown that teachers are partially competent in developing original analogies, and they need to be informed about analogies and develop analog reasoning skills (Dönder, 2010). It can be said that teachers' lack of strong pedagogical content knowledge about analogies affects students. After all, the requirement for students to be successful in activities in which they draw analogies can be met by teachers' extensive pedagogical content knowledge about analogies (Mozzer & Justi, 2013). At the same time, teachers' perception that analogies are redundant, intensive content requirements in science curricula, and the lack of readily available analogical models are why teachers do not use analogies in their classrooms (Berber & Sarı, 2009). That indicates that teachers are avoiding analogies due to their incompetence in analogies and that more research should be conducted about the role of analogies in science education and teacher training. In analogy studies conducted according to various variables, it was stated that gender did not have any effect, but males were more likely to use analogies. However, females are better at visual and spatial skills when compared to males (Özcan, 2019; Pittman, 1999). It can be said that this situation varies based on the type of analogies. In document analysis, it was obtained that the analogies used in textbooks were limited and straightforward, did not enrich the concept, and the limitations of the analogies were not provided for students. At the same time, it was stated that an insufficient amount and quality of analogies were used (Çalık & Kaya, 2012; Taber, 2013). It is thought that more examples of analogies are provided, and further studies should be carried out to find solutions to these issues.

CONCLUSION

The findings show that although analogy studies do not follow a distinct course, they were carried out more intensively in the early 2009s, but the most common year was 2012. It appears that the analogy studies have lost their popularity. On the other hand, it is observed that analogy studies are carried out less in biology than in other fields and that most studies are carried out in the field of chemistry. There is a lot of work in chemistry that suggests that the use of analogy may be more effective in chemistry that includes a lot of abstract topics and concepts. Another finding that supports the idea that analogy is an effective technique for teaching and learning abstract concepts is that analogies are used more often at a younger age, so abstract thinking is not well developed. According to the findings obtained from the study; studies using analogy technique are frequently reported to be carried out with high school students (Ketenci, 2019; Kobal, 2011), elementary school students (Taşkara, 2015; Ünlü, Dökme, 2011), and then with pre-service teachers (Haglund & Jeppsson, 2012; Kurt, 2019; Türk, Ayas & Karslı, 2010). It is noteworthy that the studies that examined textbooks focused on middle school the most and high school physics textbooks the least. It would be considered a contradiction to the previous comment. However, it also supports that younger students can learn easily with analogies. When we look at the data collection tools used in these studies involve analogies; achievement and concept tests (Çalık, Ayas & Ebenezer, 2009; Çoban, 2019), and interviews are used often (Ashe & Yaron, 2013; Çalık & Kaya, 2012; Haglund, 2013; Harman & Çökelez, 2017). Similar to other research conducted in science education, frequently used data collection tools were achievement tests, scales, and interviews. In addition, it was revealed that studies using a mixed-method approach were less common, and using multiple data sources was not common practice either. When we look at the aims and research methods of the examined studies, it is seen that most of the qualitative research includes document analysis of the textbook.

On the other hand, the quantitative studies utilized experimental design to test the effects of analogies on

student achievement. In addition, studies aiming to determine the misconceptions and analogy competencies of the participants (Aykutlu & Şen, 2012; Muştu & Özkan, 2017) has been carried out. Similarly, the cognitive characteristics of the participants are tried to be determined in these studies.

The studies examined have reported positive results that analogies improve the academic achievement of the students (Arıcı, 2018; Çoban, 2019; Zorluoğlu & Sözbilir, 2016). Research also suggests that pictorial representations can help students develop better performance in analogical reasoning and problem-solving skills (Lin, Shiau & Laawrenz, 1996). With the right instructional design, teaching activities involving analogy can lead to logical thinking and encourage creative thinking. The suggestions included in the studies examined were collected in future research, teacher training, material development, and classroom practice. It has been suggested that research should focus on the relationship between age groups and analogy types to find out more effective analogies for a certain age (Gökharman, 2013; Yamaç, 2016). Another suggestion highlights the need for research on the suitability of the analogies used for students' cognitive levels. One of the most mentioned suggestions in improving pre-service and in-service science teacher training programs by adding a module about how to teach by using analogies. (Marcelos & Nagem, 2012; Ören, Ormancı, Babacan, Çiçek, Koparan, 2010).

SUGGESTIONS

This study shed light on the analogy studies carried out since 2009. In this context, the researchers working in the field were tried to be guided about the deficiencies in the direction of the subject areas, the methods used, and the findings obtained from the results. In this way, it is thought that the educators in the field will be able to make remarkable studies and applications that fill the gap in the field related to the role of analogies in science education. The following suggestion emerges from the discussions and conclusions:

1. It is understood that the studies generally focus on document analysis and achievement, but little or no attention was paid to different analogical learning approaches. Therefore, it is considered that conducting studies involving different learning approaches in analogy would be better in filling the gap in science education literature about analogies.
2. When the purpose and methodology of the studies were examined, it was found that the studies could not go beyond basic research that determines the situation, and experimental studies were less common. In this context, it is thought that there is a need for in-depth applied research rather than surveys.
3. It is seen that scales, questionnaires, interviews, and achievement tests were used as data collection tools. On the other hand, it is understood that alternative assessment tools such as rubrics, drawing, and self-assessment were rarely employed. Therefore, it is believed that it will be important in the literature to focus on studies in which quantitative and qualitative data collection tools are used together, and data diversification is carried out. In addition, more contemporary techniques, including eye movement behaviors of students, can be specifically addressed to provide supportive evidence that aims better to reveal students' cognitive processes during analogical learning.
4. Studies show that although the participants have positive attitudes and views towards analogies, they have insufficient knowledge about analogy use. This situation reveals that teachers should be supported cognitively and pedagogically. In this context, it is thought that there is a need for practical experimental studies that teachers can obtain about the use of analogy. To improve this situation, governments or NGOs can create a common platform for science teachers in the form of a web page to enhance teachers' analogy development competencies and provide an open-source platform for sharing well-developed materials and good experiences.
5. Computer and mobile tools should be included in the learning-teaching process. This process might also reveal their existing misconceptions. To present activities for making analogy as a measurement and evaluation tool can be used as an alternative approach to providing conceptual change, which seems to be paid less attention in examined studies

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