ORIGINAL ARTICLE

The Effect of Teaching the Secondary School 7th Grade Cell and Division Unit with Concept Map on the Academic Success of Students¶

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***Abstract**: This study aims to determine the effect of teaching the "Cell and Divisions" unit in the science course with concept maps on the academic achievement of 7th grade middle school students. In order to achieve the stated purpose, a mixed method approach using an explanatory sequential design was used. The study group of the research consisted of 30 middle school students studying in the 7th grade. Convenience sampling method was used in sample selection. In this five-week long implementation, the control group was taught by the teacher according to the current science curriculum in the textbook, while the experimental group was taught a lesson enriched with concept maps. Quantitative data were obtained with the Science Attitude Scale (SAS) and the Cell and Divisions Achievement Test (CCDAT). The "Semi-structured Interview Form" developed by the researchers was used as a qualitative data collection tool. Descriptive statistics, Mann Whitney U test and Wilcoxon Signed Rank test were used to analyze quantitative data. Qualitative data were analyzed descriptively by content analysis method. In the post-application analysis results, while there was no statistically significant difference between the pretest results of the control and experimental groups, statistically significant results were found in favor of the experimental group in the post-test academic achievement scores. Interviews with the students revealed that concept maps contributed significantly to their learning.*

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Introduction

WITH THE emergence of international competition in the fields of science, physics, and technology in the past century, the importance of science education has rapidly increased in various areas (Akdeniz et al., 2000; Tekindur, 2022). Science education stands out among the courses that can provide these characteristics (Aydın & Kılıç-Mocan, 2022). Science education aims to develop problem-solving skills through mental processes rather than memorizing and solving problems (İncekara, 2023).

Although science-related concepts are taught correctly in school, students may need clarification about these concepts in their minds in everyday life (Kutluca, 2021). Therefore, it is necessary to prefer teaching methods that can attract students' interest in science classes and enable them to connect new knowledge with prior knowledge (Çiftçi & Aydın, 2023). Concepts categorize similar objects, people, events, ideas, and processes (Bulut et al., 2021). They are the building blocks of knowledge and enable the categorization of knowledge in the mind. There are numerous concepts and relationships between concepts in science courses. Therefore, teaching concepts is crucial in science education (Aydın & Balım, 2007).

The methods of instruction which are used in a course have a significant impact on obtaining effective results from the learning process. Individuals must reorganize and store their perceptions with previously acquired knowledge for meaningful learning (Ülgen, 1997). Concept maps play an important role in meaningful learning and are one of the methods for associating, structuring, and visualizing information in individuals' minds. Concept maps are tools to facilitate meaningful learning and the transfer of information to long-term memory (Oluk & Ekmek ̧i, 2017).

Concept maps are developed based on David Ausubel's theory of Meaningful Learning. Ausubel believes that new information needs to be integrated with existing information (Çiftçi & Aydın, 2023). Concept mapping is a teaching method that visualizes the interconnected relationships between concepts from general to specific (Akbaş, 2019). As they create concept maps, students learn to connect concepts logically (Turan-Oluk & Ekmek ̧i, 2016). In these learning processes, teachers can observe students' thinking processes. It is possible in this way to identify the concepts in which students are struggling to learn, and corrections can be made regarding their misconceptions (Yıldırım & Çelik, 2022).

The studies in the literature on concept mapping indicate that concept maps enhance students' academic achievement and motivation when created together with students (Aslan, 2022; Bulut, 2021; Demirci & Memiş, 2021; Güçlüer, 2006; Sarıkaya et al., 2010; Üstün, 2003). However, it is observed that the number of studies on using the concept mapping technique for the

7th-grade cell and division unit is insufficient in the literature. Furthermore, studies indicate that students find it challenging to understand the processes related to cell division as concepts such as chromosome, homologous chromosome, and chromatid are confusing (Knippels et al., 2005). Additionally, cell and division topic can be challenging for students in terms of visualizing and structuring concepts in their minds (Aksakal et al., 2015).

Orak (2022) investigated the impact of concept mapping-based education based on a constructivist approach on students' academic achievement and attitudes in terms of teaching the topic of renewable energy sources in science. The research indicated that the experimental group receiving concept mapping-based education had a higher score increase. The studies by Elmas et al. (2022) and Bulut et al. (2022) reported that teachers rarely use concept maps for assessment purposes. Elmas et al. (2022) attributed it to the teachers' inclination towards traditional assessment methods. They stated that it was due to the large class sizes and limited time.

Considering that the current education system values the relationships between information more than rote memorization, this study explores the importance of concept maps and their impact on student learning by investigating their effect on student achievement. This study can be beneficial for all fields within the evolving education process. This research aims to answer the following question: What is the effect of teaching the "Cell and Division" unit to 7th-grade middle school students using concept maps on their academic achievement?

The research subproblems which were formulated within the scope of the defined problem statement are as follows:

1. Is there a statistically significant difference between the attitudes of the experimental and control groups towards science classes?
2. Is there a statistically significant difference between the experimental and control groups' pretest scores regarding academic achievement?
3. Is there a statistically significant difference between the academic achievement pretest and post-test scores of the control group?
4. Is there a statistically significant difference between the experimental group's academic achievement pretest and post-test scores?
5. Is there a statistically significant difference between the experimental and control groups' post-test scores in terms of academic achievement?
6. What are students' opinions regarding teaching the cell and division topic using concept maps?

Figure 1. Early Models of Pro-Environmental Behavior.

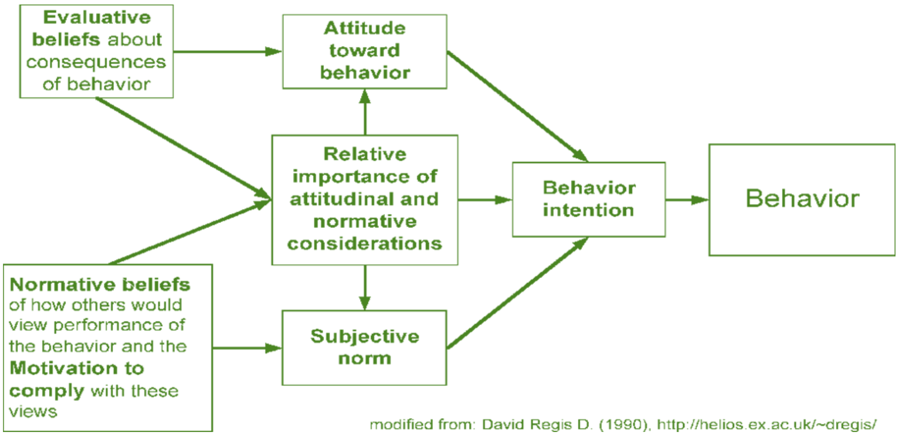

Figure 2. Theory of Reasoned Action (Ajzen & Fishbein, 1980).

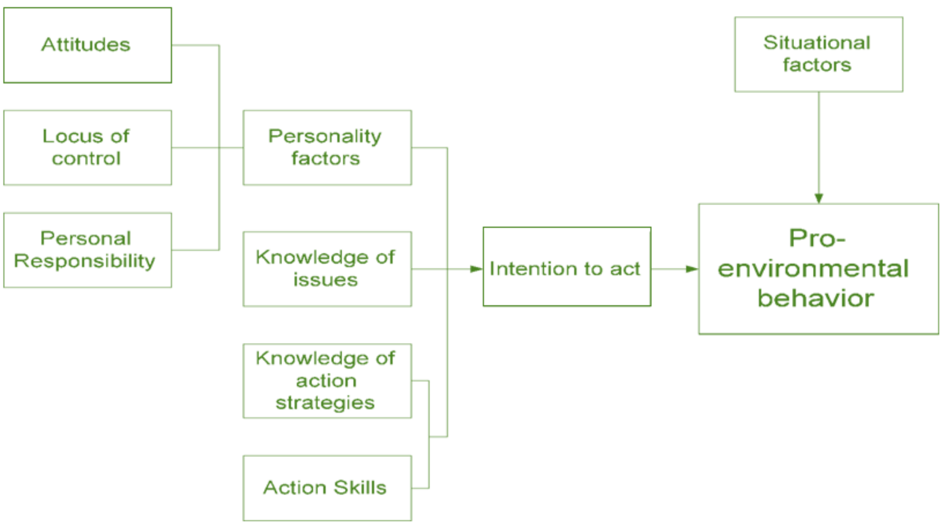

Figure 3. Models of Predictors of Environmental Behavior (Hines et al., 1986).

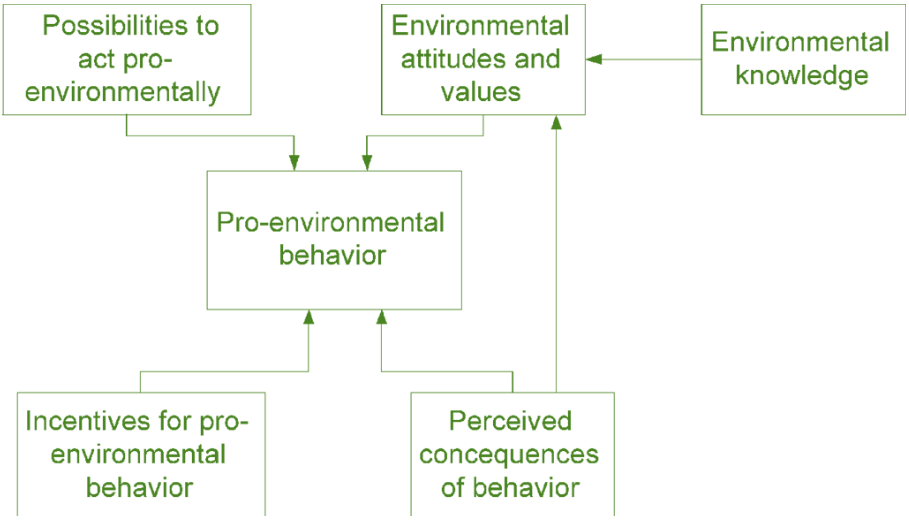

Figure 4. Model of Ecological Behavior (Fietkau & Kessel, 1981).

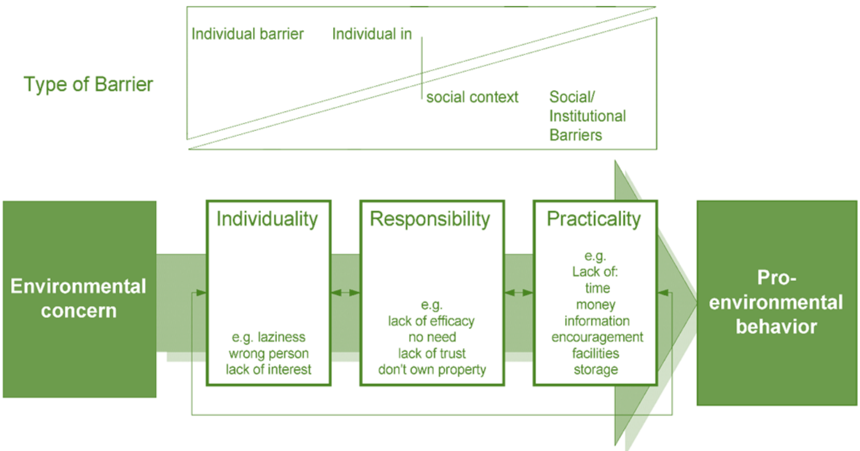

Figure 5. Barriers between Environmental Concern and Action (Blake, 2007).

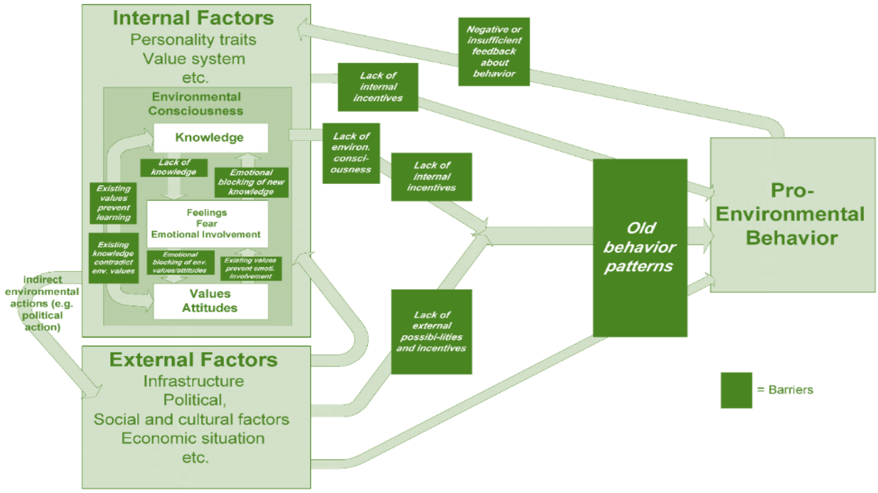

Figure 6. Model of Pro-Environmental Behavior (Kollmuss & Agyeman, 2002).

Method

Research Design

This study employed a mixed-methods approach using an explanatory sequential design. Mixed methods involve quantitative and qualitative methods to obtain more reliable data on the research topic (Şimşek, 2015). In an explanatory sequential design, quantitative data is collected and analyzed first, followed by qualitative data acquisition.

Individual quantitative and qualitative data analyzes are integrated and interpreted in the discussion section (Cresswell, 2008). A quasi-experimental method was employed to test the effectiveness of the application. It aims to determine the application's impact on the participants.

Study Group

The research was conducted with 7th-grade students from a public middle school in the Central Anatolian Region in Türkiye. Fifteen students were in the control group, and 15 were in the experimental group. The groups were formed as two classes so that the academic achievement levels were balanced based on the average scores from previous years. The study was conducted during the fall semester of the 2021-2022 academic year. In the qualitative phase of the study, interviews were conducted with the students in the experimental group to determine their opinions on the concept mapping technique.

Data Collection Tools

Science Attitude Scale (SAS)

Before starting the study, an attitude test was applied to the students in the experimental and control groups to assess their attitudes towards the science course, as the differences in the attitudes between the groups could potentially affect the effectiveness of the applied method. The Science Attitude Scale (SAS), developed by Keçeci and Kırbağ-Zengin (2015), was used with the necessary permissions obtained from the developers. The scale consists of 31 five-point Likert-type items. The response options for the test are "strongly disagree, disagree, neither agree nor disagree, agree, strongly agree." The reliability of the scale was calculated as 0.90 by the developers. Additionally, our reliability assessment for the scale yielded a value of 0.92, indicating reliability.

Cell and Division Achievement Test (CDAT)

In order to obtain quantitative data at the beginning of the study, measure the students' prior knowledge of the topic, and assess their final achievement at the end of the research, a multiple-choice CDAT scale (Coşkun, 2019) was used after the necessary permission was obtained from the author. CDAT scale consists of 25 items and was used to collect quantitative data. The test development studies by Coşkun (2019) defined the reliability coefficient of the test as 0.78 through KR-20 analysis. Our reliability calculations yielded a KR-20 reliability coefficient of 0.80. It indicates that the test is reliable.

Interview Form

The qualitative data in the study was obtained through semi-structured interviews. After the researchers developed the semi-structured interview form to collect qualitative data, it was reviewed by two field experts. Then, the final version of the interview form was applied to the 15 students in the experimental group. The form which was used in the interview aims to gather students' opinions on the concept mapping technique and includes questions such as "What benefits did this technique provide for you?", "Did you encounter any difficulties with this technique?" "Do you think there are any negative aspects of the teaching method we applied in this unit that you did not like?" Experts in the field reviewed the questions in the interview form to ensure their suitability for the primary purpose of the thesis. It also serves to ensure its content validity (Eroğlu, 2009). Additionally, the coefficient of agreement between the experts was calculated to be 0.86.

Data Collection

This study collected quantitative data with a single-group quasi-experimental method. Before the implementation, the class of 30 students was divided into two groups of 15 students, each according to their science course averages in the previous years. Before the implementation phase, an attitude test was administered to both groups to determine the student's current attitudes towards the science course. Then, the "Cell and Division Achievement Test" (CDAT) was applied as a pretest. The pretest scores showed that students in both groups had similar prior knowledge about the topic. The same teacher taught the selected topic in both control and experimental groups for 20 lesson hours for five weeks, starting from the lesson following the test. In the experimental group, the concept mapping technique was introduced to the students, concept maps were actively used at every stage of the lessons, and students were encouraged to create their maps. The lessons in the control group were taught according to the existing science curriculum in the textbook. The CDAT was administered again as a post-test to determine the academic achievement levels of the students in the control and experimental groups. After the quantitative data were collected, statistical analyzes were performed. Qualitative data were then collected to explain the results of the quantitative data. The researchers prepared A semi-structured interview form to collect qualitative data.

Data Analysis

The data analysis in the study was conducted using the IBM-SPSS v25 software package. First, the variables' conformity to the normal distribution was tested.

According to the Shapiro-Wilk test, the data obtained from the CDAT pretest, CDAT post-test, and Science Attitude Scale were found to have a normal distribution within the single group and the control and experimental groups. However, the Shapiro-Wilk test indicated that the post-test results as a single group did not exhibit normality. Some of the histogram graphs showed results close to the standard distribution curve, and the division of skewness-kurtosis values by their standard errors resulted in a value of + - 1.96 (George & Mallery, 2016; Tabachnick & Fidell, 2006). However, considering the size of the data set, it is more appropriate to use non-parametric tests for groups with less than 20 samples (Büyüköztürk, 2011). In this regard, the Wilcoxon test was used to determine the difference between the pretest and post-test within the groups, and the Mann-Whitney U test was used to determine the difference between the control and experimental groups in terms of the pretest, post-test, and Attitude Scale. According to Fritz, Morris, and Richler (2012, p.12), the effect size (r) is calculated to state the statistical difference in Mann-Whitney U and Wilcoxon Marked Rows tests. Cohen (1992) stated that an r value of 0.10 should be considered small, 0.30 moderate, and 0.50 large effect size. The square of the effect size (r^2) is used to determine how much of the difference in the dependent variable results from the independent variable (Cohen, 1988).

In the evaluation of qualitative data, the students' statements were transcribed and subjected to descriptive content analysis. The interview data were evaluated individually for each student, and example student statements were directly presented.

Findings

The first research question investigated whether there is a statistical difference between the experimental and control groups' attitudes towards science. **Table 1** shows the results of the Mann-Whitney U Test conducted to determine the difference between the experimental and control groups in terms of their attitudes towards science.

According to **Table 1**, it has been determined that there is no statistically significant difference in the attitudes towards science of the experimental (Median Rank = 16.37, $p > 0.05$) and control (Median Rank = 14.63, $p > 0.05$) group students.

The second research question investigated whether there is a statistically significant difference between the pretest scores of the experimental and control groups in terms of academic achievement. **Table 2** presents the results of the Mann-Whitney U Test conducted to determine if there is a difference in the pretest scores between the experimental and control groups regarding their achievement in CDAT.

As seen in **Table 2**, no statistically significant difference was determined in the achievements obtained from the pretest CDAT between the experimental group (Rank Sum = 14.93, $p > 0.05$) and the control group (Rank Sum = 16.07, $p > 0.05$) of students.

The third research question investigated whether a statistically significant difference exists between the control group's academic achievement pretest and post-test scores. **Table 3** presents the results of the Wilcoxon Test, which was conducted to determine whether there is a difference between the control group's post-test and pretest scores regarding their achievement in CDAT.

The pretest and the post-test scores of the control group were examined in **Table 3**. It can be stated that CDAT post-test achievements are

Table 1. Mann Whitney U Test Result on the Attitudes of Experimental and Control Groups towards Science Course.

Variable	Group	N	Avg. Rank	Total Rank	*U*	Z	p
Attitude	Control	15	14.63	219.50	99.500	-0.541	0.595
	Experimental	15	16.37	245.50			

Table 2. Mann Whitney U Test Results for Pretest Scores Obtained from CDAT by Experimental and Control Groups.

Variable	Group	N	Avg. Rank	Total Rank	U	Z	p
CDAT	Control	15	16.07	241.00	104.000	-0.357	0.744
	Experimental	15	14.93	224.00			

Table 3. Wilcoxon Test Results for the Control Group's Post-Test and Pretest Scores in CDAT.

Variable	Pretest Post-Test	N	Avg. Rank	Total Rank	Z	p
Control	Negative Rank	5	4.17	12.50	-2.315*	0.021**
	Positive Rank	10	7.85	78.50		

**Based on the Negative Ranks; **p<0.05*

significantly higher than pretest achievements ($z = -2.315$, $p < 0.05$). The calculated effect size is $r = 0.60$, indicating a large effect. Additionally, 36% of the difference (r^2) can be attributed to the independent variable (teaching method). Therefore, it can be concluded that the lessons taught according to the current science curriculum in the textbook impact students' learning of the subject.

The fourth research question investigated whether a statistically significant difference exists between the experimental group's academic achievement pretest and post-test scores. Wilcoxon Test results are provided in **Table 4** to determine if there is a significant difference between the post-test and pretest scores of the experimental group in terms of CDAT achievement.

According to **Table 4**, the pretest and post-test scores of the experimental group were examined. It can be stated that the students' CDAT post-test achievements are statistically significantly higher than their pretest achievements ($z = -3.421$, $p < 0.05$). The calculated effect size is $r = 0.88$, indicating that the implemented intervention has a substantial effect. Furthermore, 77% of the difference (r^2) can be attributed to the independent variable (concept mapping application). Therefore, it can be concluded that the concept mapping instructional model is effective for students.

The fifth research question investigated whether there is a statistically significant difference between the experimental and control groups' post-test scores in terms of academic achievement. The results of the Mann-Whitney U Test, which was performed to determine whether there is a difference between the post-test results of the experimental and control groups in their achievements in CDAT, are given in **Table 5**.

According to **Table 5**, CDAT post-test achievements in the Experiment (Rank Mean = 23.00, $p < 0.05$) and Control (Rank Mean = 8.00, $p < 0.05$) groups show a statistically significant difference. The calculated effect size is $r = 0.86$, indicating the application has a substantial effect. 74% of the difference (r^2) is due to the process applied (concept mapping application). Given these results, it can be stated that teaching cells and division supported by the concept mapping applied to students is more effective than the current science curriculum in the textbook.

The sixth research question investigated students' opinions regarding teaching the cell and division topic using concept maps. The findings of how students found the technique applied in the course are given in **Table 6**.

Table 6 analyzes students' answers to the interview question: "How did you feel about the course processing technique we applied in the cell and division unit?" The most frequency-generating code (f = 11) was "easy and persistent". The code (f = 2) that generated the second highest frequency was "fun". In addition, the expressions (f = 1) "concise and concise" and (f = 1) "visualizer" were also expressed by one student each. In this regard, the following examples can be given to students' answers:

"I think that this technique was fun." (S8)

"... it is impressive that it presents the subject visually" (S2)

"... presents the subject shortly and concisely." (S12)

"... a technique that makes us easy to grasp and minimises forgetting." (S1)

The findings for the benefits of the applied technique are given in **Table 7**.

According to the information in **Table 7**, the student answers to the interview question "What benefits the applied technique has provided you?"

Table 4. Wilcoxon Test Results for the Post-Test and the Pretest Scores of the Experimental Group in CDAT Achievement.

Variable	Pretest Post-Test	N	Avg. Rank	Total Rank	Z	p
Experimental	Negative Rank	0	0.00	0.00	-3.421*	0.001**
	Positive Rank	15	8.00	120.00		

Table 5. The Results of Mann Whitney U Test on the Difference between the Post-Test Results of the Experimental and Control Groups in Their Achievements in CDAT.

Variable	Group	N	Avg. Rank	Total Rank	U	Z	p
CDAT	Control	15	8.00	120.00	120,000	-4,690	0.000*
	Experimental	15	23.00	345.00			

Table 6. Findings on How Students Regard the Technique Used in the Course.

Code	F
Easy and Lasting	11
Short and concise	1
Illustrative	1
Entertaining	2

Table 7. Findings for the Benefits of Applied Technique.

Code	F
Visualization of learning	8
Connection building within the topic	2
Simplification of the subject	1
Facilitation of learning	1
Encouraging the student	3

are examined. The most frequency-generating code (f = 8) was "visualization of the subject", and the second most frequency-generating code (f = 3) was "encouraging the student". The third code (f = 2) that created the most frequency was "connection building within the topic", and the fourth code (f = 1) that formed the least frequency was "simplification of the subject" and "facilitation of learning". In this regard, the following examples can be given to students' answers:

"It encouraged me to learn about the topics in this unit, so it motivated me." (S13)

"It has a facilitating effect on the subject." (S1)

"... has a visualizing effect." (S11)

"Thanks to the arrows on the map, I learned how words relate to each other." (S9)

"It gave a simplifying effect on the subject." (S5)

The findings on why the applied technique is useful are given in **Table 8**.

Table 8 examines the student answers to the interview question "Why do you think this technique is useful?" The most frequency-generating code (f = 9) was "revealing different views", and the second most frequency-generating code (f = 2) was "providing easy learning". The third most frequent codes (f = 1) are "providing a fun learning environment" and "providing detailed learning". In this regard, the following examples can be given to students' answers:

"... enabled us to learn the information in detail." (S8)

"... allowed us to learn topics easily..." (S13)

"... topics become much fun" (S15)

"Information becomes more permanent" (S10)

"It is useful because different ideas are united in one picture." (S6)

The findings for the disadvantages of the applied technique are given in **Table 9**.

Table 8. Findings on Why the Applied Technique is Useful.

Code	F
Revealing different views	9
Providing permanent learning	2
Creating a fun learning environment	1
Providing easy learning	2
Providing detailed learning	1

Table 9. Findings on the Disadvantages of the Applied Technique.

Code	F
There is no negative aspect.	13
Complicated	1
Time-consuming	1

Table 10. The Findings on the Effects of the Negative Aspects of the Applied Technique on Student Learning.

Code	F
It did not affect me negatively	13
I was hard at first	1
It took time	1

Table 11. Findings on Where Students were Challenged Most When Applying the Technique.

Code	F
I had no difficulty	13
I had a hard time understanding	1
It took too much time	1

Table 9 analyzes the students' answers to the interview question: "Are there any negative/disliking aspects of the technique we applied in the cell and divisions unit?" The most frequency-generating code (f = 13) was "no negative aspect", and the second most frequency-generating codes (f = 1) were "complex" and "time-consuming". In this regard, the following examples can be given to students' answers:

"... it takes time to draw a concept map." (S14)

"Some concept maps are complex." (S15)

"Not negative this technique never..." (S12)

The findings on the negative effects of the applied technique on student learning are given in **Table 10**.

Table 10 analyzes the student answers to the interview question: "Did these negatives affect your learning? If yes, how did it affect you?" The most frequency-generating code (f = 13) was "no negative aspect", and the second most frequency-generating codes (f = 1) were "I was hard at first" and "it took time". In this regard, the following examples can be given to students' answers:

"Concept maps took much time." (S2)

"At first, I had a hard time understanding concept maps." (S1)

"... my learning was unaffected." (S15)

The findings on where students were challenged most when applying the technique are given in **Table 11**.

Table 11 analyzes the students' answers to the interview question: "Where did you have the most difficulty?" The most frequency-generating code (f = 13) was "I had no difficulty", and the second most frequency-generating codes (f = 1) were "I had a hard time understanding" and "It took too much time". In this regard, the following examples can be given to students' answers:

"... ... it takes time to draw a concept map." (S2)

"I had a hard time understanding some concept maps." (S1)

"... I can state that I had no difficulty." (S3)

Table 12. Findings on Whether This Technique Was Useful When Used by Students while Studying at Home.

Code	F
It was absolutely useful	11
It was partly useful	3
It would definitely be useful if I had used it	1

Table 13. Findings on Whether Students Want to Use the Applied Technique in Other Units of Science Course.

Code	F
All science topics	9
Force and movement	1
Systems in our body	2
Matter and its nature	2
Conduction of electricity	1

After learning the applied technique, the findings on whether this technique was useful when used by students while studying at home are given in **Table 12**.

Table 12 shows the answers to the question, "Do you think it is useful to use the applied technique when studying at home?" The most frequency-generating code (f = 11) was "It was absolutely useful", and the second most frequency-generating code (f = 3) was "It was partly useful". The third most frequency-generating code (f = 1) was "it would definitely be useful if I had used it". In this regard, the following examples can be given to students' answers:

"... I did not use it, but I think it would definitely be useful if I had used it." (S2)

"It benefited me in some ways" (S10)

"It was definitely useful when I used it..." (S9)

The findings of whether students want to use the applied technique in other units of science course are given in **Table 13**.

Student answers to the interview question "Do you want this technique to be used in other units in science course?" are analyzed in **Table 13**. The most frequency-generating code (f = 9) was "all science topics", and the second most frequency-generating codes (f = 2) were "systems in our body" and "matter and its nature". The codes that generated the third highest frequency (f = 1) were the units of "force and movement" with "conduction of electricity". In this regard, the following examples can be given to students' answers:

"I would like it to be used in the unit conduction of electricity." (S1)

"I would like it to be used in the unit matter and its nature."

"I would like it to be used in the unit systems in our body" (S12)

"I would like it to be used in the unit force and movement." (S6)

"I would like it to be used in all topics of science." (S13)

In addition, the experimental group students identified concept maps as a useful technique during the interview. While 13 students did not regard concept maps as a challenging technique, two students stated they had little difficulty. Fourteen students stated that they used the concept maps technique while studying at home, but one student stated that they did not use it at home.

Discussion and Conclusion

The present research investigated the effect of teaching the "Cell and Division" unit in the science lesson of secondary school 7th-grade students with concept maps on the academic achievement of the students. Since students' attitudes towards the course could affect their academic achievement, both groups' attitudes to the course were evaluated before the study. As a result of the analysis, no statistically significant difference was obtained between the groups. According to this result, it was found that the students in both groups had equal attitudes towards the science course. Therefore, it is acceptable that the difference that may arise from teaching will result from the method.

In comparing the control group's achievement in cell and division pretest and post-test averages, a statistically significant increase was determined in the students' post-test achievement averages compared to their pretest achievement averages. This increase in student achievement concludes that teaching the topic based on the current science curriculum in the textbook is effective for students' academic success. The comparison between the experimental group's cell and division pretest and post-test averages concludes an increase in student achievement with a statistically significant difference when teaching the topic with the support of concept maps. This increase in student achievement reveals that teaching the topic with a concept map is effective for student academic success.

The current science curriculum in the textbook and the teaching model supported with concept maps effectively affect students' success. However, the relationship between the post-tests of the control and the experimental group should be examined to determine which model is more effective on student achievement.

The analyses were studied to determine whether the experiment and control groups observed a statistical differentiation in their cell and division post-test scores. The findings revealed that the academic achievements of the experimental group in which concept maps were used were more positively influenced than the current science curriculum in the textbook.

The students stated that they found concept maps to be a fun technique that provides easy and persistent information shortly and concisely, facilitating learning with visuals. All the students who participated in the interview regarded concept maps as useful. The findings demonstrated that 87% disagreed that there may be a negative aspect of concept maps. About 93% of the participants said they used concept maps while studying at home. As all participants provided the name of a topic for which concept maps can be used in science courses, the students found this technique useful.

According to Bahar, Johnstone, and Hansell (1999), students are challenged in biology due to the abstraction of the concepts of biology and the complexity of their relation to each other. Lewis and Wood-Robinson (2000) argue the necessity of teaching genetic terminology in an order as the structure of information and then the interpretation of information for quality education.

In the present study, the topic of cell and divisions was instructed with the support of concept maps. It was observed from the analysis of quantitative findings that the experimental group knew the concepts of cell divisions and phases of cell divisions. Based on these results, it may be concluded that the concept-maps-assisted education contributed positively to students' academic success. In this regard, the present study parallels the study by Bahar, Johnstone, and Hansell (1999) and Lewis and Wood-Robinson (2000).

Banet and Ayuso (2000) and Stewart (2011) reported that chromosome and gene relationships are difficult to learn, and the current methods and books must change. Özatlı (2006), Özdemir (2005), Saka and Akdeniz (2006), and Temelli (2006) state that students have difficulty learning the concepts of cells, DNA, chromosomes, and genes and cannot make distinctions between these concepts.

In the present research, the students found it challenging to establish relationships between chromosome, gene, DNA, and nucleotide concepts. When our data was examined, it was understood that students could not identify the relationships between these concepts during the pretest stage, where their test results were low. Based on the results of the post-test, it was observed that the experimental group students were more able to establish these inter-conceptual relationships than the control group. When more concept maps are included in textbooks, students will also enhance the level of their inter-conceptual relationship. In this regard, the present study coincides with researchers such as Banet and Ayuso (2000), Stewart (2011), Özatlı (2006), Özdemir (2005), and Temelli (2006). The students stated during the interviews that they found concept maps useful and used them fondly while studying. Therefore, it can be concluded that giving more space to the concept maps in the lessons will be useful. This qualitative result supports quantitative results.

Gözmen (2008) emphasized that teaching techniques in the teaching of biology subjects should be supported by questions/answers to consolidate knowledge. Şahin and Ulucan (2023) concluded in their studies that rather modern and different teaching techniques should be preferred for students to learn concepts. In the present study, the achievement test averages of the experimental group are statistically higher than that of the control group. These results are in parallel with the work done by Gözmen (2008) and Şahin and Ulucan (2023). In addition, concept maps were described as a useful method by students in the interviews. These results also support the quantitative data in the present study. Gözmen (2008) emphasized that the science textbooks in our country are lacking in supporting the goals of science education, and they consequently do not provide opportunities for meaningful learning. Therefore, they concluded that activities and teaching supported with different techniques will positively contribute to the students.

In the present study, the experimental group students indicated they enjoyed being educated with the concept map. It can be said that this element affects the increase in students' achievements in this group. In this context, the present study is similar to the study by Gözmen (2008). In addition, the answers to the interview questions include the students stating that they achieved permanent learning with the concept maps. Another significant conclusion from the interviews is that, as the same teacher conveyed the topic to both groups, the difference resulted from the technique used. This determination indicates that the present qualitative results support the quantitative results of the present study.

Karacı and Güleç (2019) stated that using concept maps moves students forward in terms of academic achievement compared to traditional methods. Oluk and Ekmekçi (2017) stated that it is appropriate for students to create a concept map with their knowledge in order to observe the relationships among the science concepts. It has been determined in the present study that the students who created concept maps were more successful academically than the other students. Since there was a discussion environment in the groups trying to create concept maps, the students could state their ideas freely. It has been observed that the students who learn the concepts incorrectly had the chance to learn correctly from their classmates. Therefore, our study contains results similar to the studies by Karacı and Güleç (2019) and Oluk and Ekmekçi (2017). The experimental group students indicated in the interviews that they often used concept maps to answer questions. In addition, the fact that they stated they had used this technique while studying at home reveals that concept maps are an important factor in understanding the subject. Qualitative data obtained in this context support the quantitative data in the present study.

In their study, Taşkın (2017) stated that using more sensory organs in learning enables a more permanent learning experience. In concept-map-assisted education makes use of multiple sensory organs in learning. Thanks to the discussion environment during the formation of concept maps with students, they are thought to learn the topic fully, correctly, and permanently.

The present study shows a significant increase in the academic achievements of students in a positive direction as a result of the concept map-assisted educational applications. Accordingly, the present results have been produced in parallel with the studies by Taşkın (2017). It was also noted in the interviews with students that the concept maps affect students due to their visual form, which increases success. The qualitative data obtained in this context supports the quantitative data in the present study.

Bolat and Karamustafaoğlu (2021) noted that students liked the concept maps technique. Students enjoyed creating a concept map in groups, increasing their willingness to continue the course. In the present study, the students enjoyed the science course supported with concept maps. In addition, the students stated in the interviews that they would create concept maps themselves while studying, which indicates that they enjoyed this technique. In this regard, the present research has provided similar results to Bolat and Karamustafaoğlu's (2021).

Bulut, Turan-Oluk and Ekmekçi (2021) stated that the concept map technique improves students' point of view in science classes based on student interviews. In the interviews of the present study, the students stated that they learned to look at the topic from different perspectives thanks to concept maps. They also noted that the concept map technique is useful because it is persistent and relational, providing different points of view and detailed learning. They stated that they use concept maps indirectly in remembering information. Therefore, it may be said that the present finding parallels the study by Bulut, Turan-Oluk, and Ekmekçi (2021).

The students' attitudes towards science courses in the experimental and control groups in the present study are equal. In the present research, a 15-student control group studied the unit cell and divisions based on the science curriculum, while a 15-student experimental group studied it with concept maps. The research results concluded that the group supported with concept maps was more successful in academic achievement. It is assumed from the qualitative data that using concept maps may have increased success because it makes the lesson fun. In addition, creating concept maps for students enables them to see their shortcomings and allows them to manage learning processes. Accordingly, those in the experimental group were able to learn new information from their classmates and found the opportunity to correct their misconceptions.

It may be observed that there is no difference between the control and experimental groups in terms of their pretest results ($p > 0.05$, **Table 4.2**). In the post-test after the application, statistically significant results were obtained between the groups in favor of the experimental group ($p < 0.05$, **Table 4.7**). When the CDAT results of the control and experimental groups were compared, it was noted that eight problems marked incorrectly in the control group were marked correctly in the experimental group. Following the interviews conducted to explain this phenomenon, it was concluded that the element which caused this difference was the course processing technique itself. The quantitative data also supports the greater success of the experimental group in the unit "Cell and Division" with concept maps. The quantitative results coincide with the qualitative data, revealing the concept maps' effect. In this regard, the quantitative data in the present study also support the qualitative results obtained.

When the results are evaluated as a whole, it may stated that teaching lessons with concept maps increases students' interest in the lesson, allows them to learn together, encourages self-learning, prevents the formation of misconceptions, provides pleasure from learning, causes easier understanding of lessons presumed as difficult, and consequently leads to a positive effect on course achievement. When more concept maps are included in textbooks, students will also enhance the level of their inter-conceptual relationship. Thus, many of the topics regarded as difficult could be easier to learn, and meaningful learning will be achieved as well. In this respect, it is assumed to be beneficial for teachers to use this technique when teaching and to include it more in textbooks.

Recommendation

The following recommendations are presented as a result of the present study.

1. Since this study was conducted briefly, possible attitude changes could not be revealed. The science attitude scale may be applied in the form of a pretest and post-test before and after application in future studies. Students' initial attitudes towards science and after the application may be compared.
2. The study sample was limited to 30 students studying in the Central Anatolian Region in Turkey. Future studies may be planned with a greater number of students.
3. The present study is limited to the unit "Cell and Divisions" in the 7th grade science curriculum. Similar studies may be carried out in different units and topics in the science curriculum at different grades.
4. The present study compares science education supported with concept maps with the current science curriculum in the textbook. The effect of the concept mapping method is comparable to other techniques and methods based on constructivism and student-centred education.

References

Akbaş, Y. (2019). Güncel konularla sosyal bilgiler öğretimi. Yeni program ve ders içeriklerine göre sosyal bilgiler öğretimi. Pegem A Yayınları.

Aksakal, M., Karataş, A., & Laçin Şimşek, C. (2015). Mayoz bölünme konusunun öğretiminde modellerle zenginleştirilmiş laboratuvar ortamının akademik başarıya etkisi. *Pamukkale Üniversitesi Eğitim Fakültesi Dergisi*, 37(37):61-76. Available at: https://dergipark.org.tr/tr/pub/pauefd/issue/33862/374975

Aslan, E. (2022). Çeviri eğitiminde kavram haritalarının kullanımı. *Litera: Journal of Language, Literature and Culture Studies*, 32(2):885-902. DOI: https://doi.org/10.26650/LITERA2021-985648

Aydın, G., & Balım, A. G. (2007). Fen ve teknoloji öğretiminde kullanılan kavramsal değişim stratejilerine dayalı örnek etkinlikler. *Dokuz Eylül Üniversitesi Buca Eğitim Fakültesi Dergisi*, 22(1):54-66. Available at: https://dergipark.org.tr/tr/pub/deubefd/issue/25429/268281

Aydın, S., & Demirci, M. (2015). Basit ve karmaşık olarak hazırlanan kavram haritalarının fen eğitiminde kullanılmasına yönelik öğrenci görüşleri. *Fen Bilimleri Öğretimi Dergisi*, 3(2):117-126. Available at: https://dergipark.org.tr/en/pub/fbod/issue/71991/1158024

Aydın, E., & Kılıç-Mocan, D. (2022). Fen eğitiminin ortaokul öğrencilerinde üstbilişsel farkındalık üzerindeki rolünün incelenmesi. *Trakya Eğitim Dergisi*, 12(2):759-770. DOI: https://doi.org/10.24315/tred.934856

Aykanat, F. (2005). Bilgisayar destekli kavram haritaları yöntemiyle fen öğretimi. (Tez No. 159510) [Master's thesis, Gazi University-Ankara]. Yükseköğretim Ulusal Tez Merkezi.

Bahar, M., Johnstone, A. H., & Hansell, M. H. (1999). Revisiting learning difficulties in biology. *Journal of Biological Education*, 33(2):84-86. DOI: https://doi.org/10.1080/00219266.1999.9655648

Banet, E., & Ayuso, E. (2000). Teaching genetics at secondary school: A strategy for teaching about the location of inheritance information. *Science Education*, 84(3):313-351. DOI: https://doi.org/10.1002/(SICI)1098-237X(200005)84:3<313::AID-SCE2>3.0.CO;2-N

Bolat, A. & Karamustafaoğlu, S. (2021). Kütle ve ağırlık kavramlarının öğretimi: tahmin-gözlem-açıklama. *Milli Eğitim Dergisi*, 50(230):663-687. DOI : https://doi.org/10.37669/milliegitim.702128

Bulut, Ö. L., Oluk, N. T., & Ekmekçi, G. (2021). Kimya öğretmen adaylarının çözeltiler ve çözünme konularındaki kavram yanılgılarının kavram haritaları ile belirlenmesi. *Gazi Üniversitesi Gazi Eğitim Fakültesi Dergisi*, 41(3):1359-1407. Available at: https://dergipark.org.tr/tr/pub/gefad/issue/67470/949065

Bulut, F., Ceylan, D., & Ceylan, B. (2022). İlkokulda kullanılan ölçme değerlendirme yöntemlerinin öğretmen görüşleri doğrultusunda incelenmesi. *Black Sea Journal of Public and Social Science*, 5(2):48-55. DOI: https://doi.org/10.52704/bssocialscience.1032984

Cohen, J. (1973). Brief notes: Statistical power analysis and research results. *American Educational Research Journal*, 10(3):225-229. DOI: https://doi.org/10.2307/1161884

Cohen, J. (1992). A power primer. *Psychological Bulletin*, 112(1):155-159. DOI : https://doi.org/10.1037/0033-2909.112.1.155

Cresswel, J. W. (2008). Educational research planning, conducting and evaluating quantitative and qualitative research. International Pearson Merril Prentice Hall.

Coşkun, H. (2019). Hücre ve bölünmeler ünitesinin arttırılmış gerçeklik teknolojisi ile öğretiminin 7. sınıf öğrencilerinin akademik başarılarına ve teknolojiye yönelik tutumlarına etkisi (Tez No. 558745) [Master's thesis, Mustafa Kemal University-Hatay]. Yükseköğretim Ulusal Tez Merkezi.

Çiftçi, B., & Aydın, A. (2023). 6. sınıf fen bilimleri ders kitabında bulunan metaforlar ve analojilerin tespiti. *Turkiye Kimya Dernegi Dergisi*, 8(1):31-48. DOI: https://doi.org/10.37995/jotcsc.1203201

Demirci,T., & Memiş, E.K. (2021). Examining the views of preservice science teachers on creating concept maps. *Science Education International*, 32:264-272. DOI: https://doi.org/10.33828/sei.v32.i3.10

Doğan, R., & Tosun, C. (2000). Din kültürü ve ahlak bilgisi öğretiminde kavram haritaları. Öğreti Yayınları.

Elmas, R., Canbazoğlu Bilici, S., Adıgüzel Ulutaş, M. & Yalçın, S. (2022). Fen öğretim programları üzerine uluslararası bir bakış. *Bulletin of Educational Studies*, 1(1):48-55. DOI: http://doi.org/10.29329/bes.2022.480.03

Gözmen, E. (2008). Lise 1. Sınıf biyoloji dersinde okutulan mayoz bölünme konusunun öğretilmesinde modellerin öğrenmeye etkisi (Tez No. 178515) [Master's thesis, Selçuk University-Konya]. Yükseköğretim Ulusal Tez Merkezi.

Güdüer, E. (2006). İlköğretim fen bilgisi eğitiminde kavram haritaları ile verilen bilişsel desteğin başarıya hatırda tutmaya ve fen bilgisi dersine ilişkin tutuma etkisi (Tez No. 189840) [Master's thesis, Dokuz Eylül University-İzmir]. Yükseköğretim Ulusal Tez Merkezi.

İncekara, A.N. (2023). Elektrik devresi konusunda simülasyon kullanılmasının öğrenci fen akademik başarıları ve fen tutumlarına etkisi (Tez No. 787622) [Master's thesis, Akdeniz University-Antalya]. Yükseköğretim Ulusal Tez Merkezi.

Karacı, A., & Güleç, M. (2019). Çevrimiçi kavram haritalarının fen bilimleri dersindeki başarı ve kalıcılığa etkisi. *Pamukkale Üniversitesi Eğitim Fakültesi Dergisi*, 46(46):271-289. DOI: http://doi.org/10.9779/pauefd.458653

Keçeci, G., & Kırbağ-Zengin, F. (2015). Ortaokul öğrencilerine yönelik fen ve teknoloji tutum ölçeği: geçerlilik ve güvenirlik çalışması. *Turkish Journal of Educational Studies*, 2(2):143-168. Available at: https://dergipark.org.tr/tr/pub/turkjes/issue/34157/377670

Knipples, M. C. J. P., Waarlo, A. J., & Boersma, K. T. (2005). Design criteria for learning and teaching genetics. *Journal of Biological Education*, 39(3):10-112. DOI: http://doi.org/10.1080/00219266.2005.9655976

Kutluca, A. Y. (2021). Exploring preschool teachers' pedagogical content knowledge: the effect of professional experience. *Journal of Science Learning*, 4(2):160-172.

Lewıs, J., & Wood-Robİnson, C. (2000). Genes, chromosomes, cell division and inheritance-do students see any relationship? *International Journal of Science Educa-*

tion, 22(2):177-195. DOI: https://doi.org/10.1080/095006900289949

Morris, P. E., & Fritz, C. O. (2012). Effect size estimates: current use, calculations, and ınterpretation. Journal of Experimental Psychology, 82:3-5.

Oluk, N.T., & Ekmekçi, G. (2017). Alternatif değerlendirme teknikleri ile klasik değerlendirme tekniklerinin öğrenci başarısını ölçme açısından karşılaştırılması. *Eğitim ve Toplum Araştırmaları Dergisi*, 4:172-199. Available at: https://dergipark.org.tr/tr/pub/etad/issue/33483/358279

Orak, G. (2022). Fen bilimleri enstitüsü yenilenebilir enerji kaynakları konusunda uygulanan kavram haritalarının öğrencilerin akademik başarı ve tutumlarına etkisi (Tez No. 769285) [Master's thesis, Amasya University-Amasya]. Yükseköğretim Ulusal Tez Merkezi.

Özatlı, N. S. (2006). Öğrencilerin biyoloji derslerinde zor olarak algıladıkları konuların tespiti ve boşaltım sistemi konusundaki bilişsel yapılarının yeni teknikler ile ortaya konması (Tez No. 180147) [Doctoral dissertation, Balıkesir University-Balıkesir]. Yükseköğretim Ulusal Tez Merkezi.

Özdemir, O. (2005). İlköğretim 8. sınıf öğrencilerinin genetik ve biyoteknoloji konularına ilişkin kavram yanılgıları. *Ondokuz Mayıs Üniversitesi Eğitim Fakültesi Dergisi*, 20:49-62.

Saka, A., Cerrah, L., Akdeniz, A. R., & Ayas, A. (2006). A cross-age study of the understanding of three genetic concepts: how do they image the gene, dna and chromose? *Journal of Science Education and Technology*, 15(2):192-202. DOI: https://doi.org/10.1007/s10956-006-9006-6

Stewart, M. (2012). Joined up thinking? Evaluating the use of concept mapping to develop complex system learning. *Assessment & Evaluation in Higher Education*, 37(3):349-368. DOI: https://doi.org/10.1080/02602938.2010.534764

Şahin, Y., & Ulucan, P. (2023). Sınıf öğretmenlerinin çeşitli öğretim yöntem ve tekniklerini kullanma durumları. *Ordu Üniversitesi Sosyal Bilimler Enstitüsü Sosyal Bilimler Araştırmaları Dergisi*, 13(1):995-1030. DOI : https://doi.org/10.48146/odusobiad.1099218

Şimşek, A. (2015). Araştırma modelleri. Eskişehir: Anadolu Üniversitesi Açıköğretim Yayınları.

Tekindur, A. (2022). Argümantasyon tabanlı bilim öğrenme yaklaşımının dördüncü sınıf öğrencilerinin fen başarısına, araştırma ve bilimsel yazma becerilerine etkisi (Tez No. 765238) [Master's thesis, Hacettepe University-Ankara]. Yükseköğretim Ulusal Tez Merkezi.

Temelli, A. (2006). Lise öğrencilerinin genetikle ilgili konulardaki kavram yanılgılarının saptanması. *Kastamonu Eğitim Dergisi*, 14(1):73-82. Available at: https://dergipark.org.tr/tr/pub/kefdergi/issue/49106/626658

Turan-Oluk, N., & Ekmekci, G. (2016). A different approach to preparing novakian concept maps: The indexing method. *Educational Sciences: Theory & Practice*, 16(6):2111-2140. DOI: https://doi.org/10.12738/estp.2016.6.0411

Utku, D. (2010). İlköğretim fen bilgisi öğretimi 7. sınıf fen bilimleri konularında kavram haritalarının kullanımı ve başarıya olan etkisi (Tez No. 159510) [Master's thesis, Gazi University-Ankara]. Yükseköğretim Ulusal Tez Merkezi.

Ülgen, G. (1997). Eğitim psikolojisi kavramlar, ilkeler, yöntemler, kuramlar ve uygulamalar. Alkım Yayınevi.

Wandersee, J. H. (1990). Concept mapping and the cartography of cognition. *Journal of Research in Science Teaching*, 27(10):923-936.

Yıldırım, G. & Çelik, M.E. (2022). Sosyal bilgiler 5. 6. ve 7. sınıf ders kitaplarının kavram haritaları açısından incelenmesi. *Uluslararası Türk Eğitim Bilimleri Dergisi*, 10(18):208-221. DOI: https://doi.org/10.46778/goputeb.969291

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