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Action Research on Improving Students' Conceptual Understanding in the "Force and Energy" Unit through Semantic Mapping

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Abstract

This study was aimed at eliminating the difficulties in teaching the concepts and the students' conceptual understanding in the "Force and Energy" unit through semantic mapping. The study was conducted using the action research method. This study was conducted in the control group using the existing learning method in the science curriculum, while in the experimental group, homework practices with semantic maps were added. The study sample comprised 49 students studying in the seventh grade of a public middle school affiliated with the Republic of Turkey Ministry of National Education [MoNE] in the 2021–2022 academic year. Data collection tools in this study were administered: the "New Force and Energy Unit Conceptual Understanding Test," the "Semantic Mapping Evaluation Rubric," and the "Implementation Interview Form." The study findings determined that the semantic mapping practice, applied to improve the conceptual understanding of the seventh grade middle school students focused on the concepts within the scope of the "Force and Energy" unit, had positive effects on the students. The results of the structured interview form to obtain the views of the seventh grade students participating in this study on the semantic mapping practice indicate that the students reinforced the subject, demonstrating more effective learning. Another result revealed that students had more fun and were more enthusiastic as they actively participated in the process. Our study results reveal that semantic mapping positively affects student performance and attitudes. From this perspective, the use of semantic mapping in the science education process can be expanded.

Keywords: Conceptual understanding, Homework, science education, Semantic mapping

Introduction

Today, considering the contemporary understanding of education, students' active participation in the education process, the mental structuring of knowledge, and its transfer to daily life are emphasized (Ülküdür, 2016). These high-level actions come to the fore owing to the multidirectional communication that occurs between teachers and students (Erciyeş, 2010). In this context, teachers should come to class prepared (Bilen, 1999), support students' active participation in the process, encourage students individually or in groups according to the content of the activity (Erciyeş, 2010), provide timely feedback in the process (Uysal, 2016), and strengthen the learning environment by treating students with unconditional love. This way, students can achieve more meaningful learning (Büyükbıçakcı, 2018).

In meaningful learning, new concepts are associated with the concepts that exist in the learner's mind (Meydan, 2018), and thus, the process results in more permanent learning (Zorlu & Sezek, 2016, 2020). Accordingly, combining different learning methods and techniques in concept learning with semantic mapping activities in modern education can enable students to concretize concepts and realize meaningful learning (Yavuz, 2006). According to Jillfitzgerald, Elmore, Kung, and Jackson (2017), semantic maps allow students to establish relationships between concepts and accomplish more meaningful learning. Semantic maps—two-dimensional visual tools that show students the names, properties, and meanings of concepts—are important tools in making learning easier and more meaningful for students (Ekici, 2014). Semantic mapping helps students concretize concepts, interpret experiences, and actively engage in the educational process, enhancing student enjoyment and participation (Aktepe, Cepheci, Irmak, & Palaz, 2017; Gürlek & Demirkuş, 2020). For this reason,

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researchers have recommended using semantic mapping as a learning tool for students of all ages in science lessons and have noted its positive effect on the structuring of the mind (Aktepe, Cepheci, Irmak, & Palaz, 2017; Badr & Abu-Ayyash, 2019; Demir & Sezek, 2009).

According to Üstünel (2016), the results obtained from studies conducted in the education and training process show that homework is one of the practices that positively affects academic achievement. The results of the process of consciously fulfilling homework requests reveal that homework requests contribute positively to academic achievement (Küçükahmet, 2001). However, for homework to have a positive impact on academic achievement, it should be relevant, and teachers should provide timely feedback and corrections for homework requests (MacBeath & Turner, 1990). In this respect, homework activities not only contribute positively to academic achievement but also affect the acquisition of individual study, self-management, and self-regulation skills (Epstein, 1988). As a matter of fact, studies examining the effects of homework activities in middle school science education lessons found that homework practice positively affects students' academic performance (Aksu & Karaçöp, 2015; Aladağ & Doğu, 2009; Arslan, 2021; Büyükkaynak, Ok & Aslan, 2016; Ersoy & Anagün, 2009; Kaya & Kaya, 2018). Moreover, the process of providing feedback on assignments increases the interaction between teachers and students (Aladağ & Doğu, 2009).

In the related literature, while research based on semantic mapping practices is scant, prior studies have mostly focused on revealing students' academic achievement to which the practice is administered (Evrekli & Balım, 2010; Tuna, 2013). Nonetheless, researchers believe implementing semantic mapping activities in terms of time and cost is possible and that these activities can be used at different levels for different purposes (Gobert & Clement, 1999; Berionni & Oliva Baldon, 2006; Demir & Sezek, 2009; Evrekli & Balım, 2010; Dilek & Yürük, 2012; Tuna, 2013; Fitzgerald, Elmore, Kung & Stenner, 2017; Aktepe, Cepheci, Irmak; Palaz, 2017; Koponen & Nousiainen, 2019; Barut, 2020; Zorlu & Zorlu, 2020; Demirkuş & Gürlek, 2020; Yolcu, Karamustafaoğlu & Karamustafaoğlu, 2021; Södervik, Nousiainen & Koponen, 2021). Additionally, Gürlek and Demirkuş (2020) have emphasized that the methods applied to concepts provide the most efficient use of existing knowledge; therefore, semantic mapping activities are valuable. From this perspective, the semantic mapping method and homework activities were integrated into the research, considering the positive effect of homework practices in the research process, and the study evaluated that realizing semantic mapping activities with homework activities that provide positive advantages in terms of learning effectiveness is important.

Before starting the research, determining the needs in the education process in a realistic way was important, and in this regard, the interview form prepared by the researchers was administered to 36 science teachers working in middle schools affiliated with the Ministry of National Education (MoNE). In the interview form, science teachers stated that they had difficulties teaching concepts and homework practices in the "Force and Energy" unit. Thus, this study included the "Force and Energy" unit. In this context, based on the information obtained as a result of the literature review, the study aimed to eliminate the difficulties in teaching the concepts in the "Force and Energy" unit by using semantic maps, and the research aimed to support the conceptual understanding of students in the "Force and Energy" unit through semantic mapping. Considering the positive effect of the semantic mapping method and homework practices in the research process, these were integrated into the research to improve the conceptual understanding of middle school students within the scope of the "Force and Energy" unit through semantic maps and to answer the following question: Do semantic mapping activities affect the conceptual understanding of middle school students in the "Force and Energy" unit?

Method

The study was conducted using the action research method. The action research method can be defined as the process of studying the actual classroom or school situation to understand and improve the quality of actions and teaching (Hensen, 1996; McTaggart, 1997; Schmuck, 1997, as cited in Johnson, 2015). Within the scope of this study, first, a needs analysis was conducted by administering an interview form to 36 science teachers working in middle schools affiliated with the MoNE in the 2021–2022 academic year. The needs analysis determined that there were difficulties in teaching the concepts in the "Force and Energy" unit and evaluated that integrating semantic mapping practices into the teaching process would provide more effective teaching for the concepts within the scope of the "Force and Energy" unit. Within the scope of the action research conducted in this regard, this study followed a mixed-method research model, using quantitative and qualitative research methods together. This study used a quasi-experimental design with a pretest-posttest control group as a quantitative research method. As a qualitative research method, this study used a case research method and emphasized the participants' views with open-ended questions. By combining quantitative and qualitative methods in the implementation process, this study aimed to increase the validity and reliability of the research and produce more qualified results in understanding and improving the current situation.

The Study Group

The study group was determined through a simple random sampling method. The study sample comprised 49 students studying in the seventh grade of a public middle school affiliated with the Republic of Turkey Ministry of National Education [MoNE] in the 2021–2022 academic year. Two classes were selected from the seventh grade level. One of these two classes was randomly selected as the experimental group and one as the control group using a simple random sampling method. There were 27 students (17 girls and 10 boys) in the experimental group and 22 students (13 girls and 9 boys) in the control group.

Research Design

This study was conducted in the control group using the existing learning method in the science curriculum, while in the experimental group, homework practices with semantic maps were added. Before the implementation, the "New Force and Energy Unit Conceptual Understanding Test" (NFEUCUT) was used as a data collection tool in the experimental and control groups. Additionally, the "Semantic Mapping Evaluation Rubric" (SMER) was used on the experimental group during the implementation. At the end of the implementation, the NFEUCUT was administered to the experimental and control groups, and the "Implementation Interview Form" [IIF] was administered to the experimental groups (Figure 1).

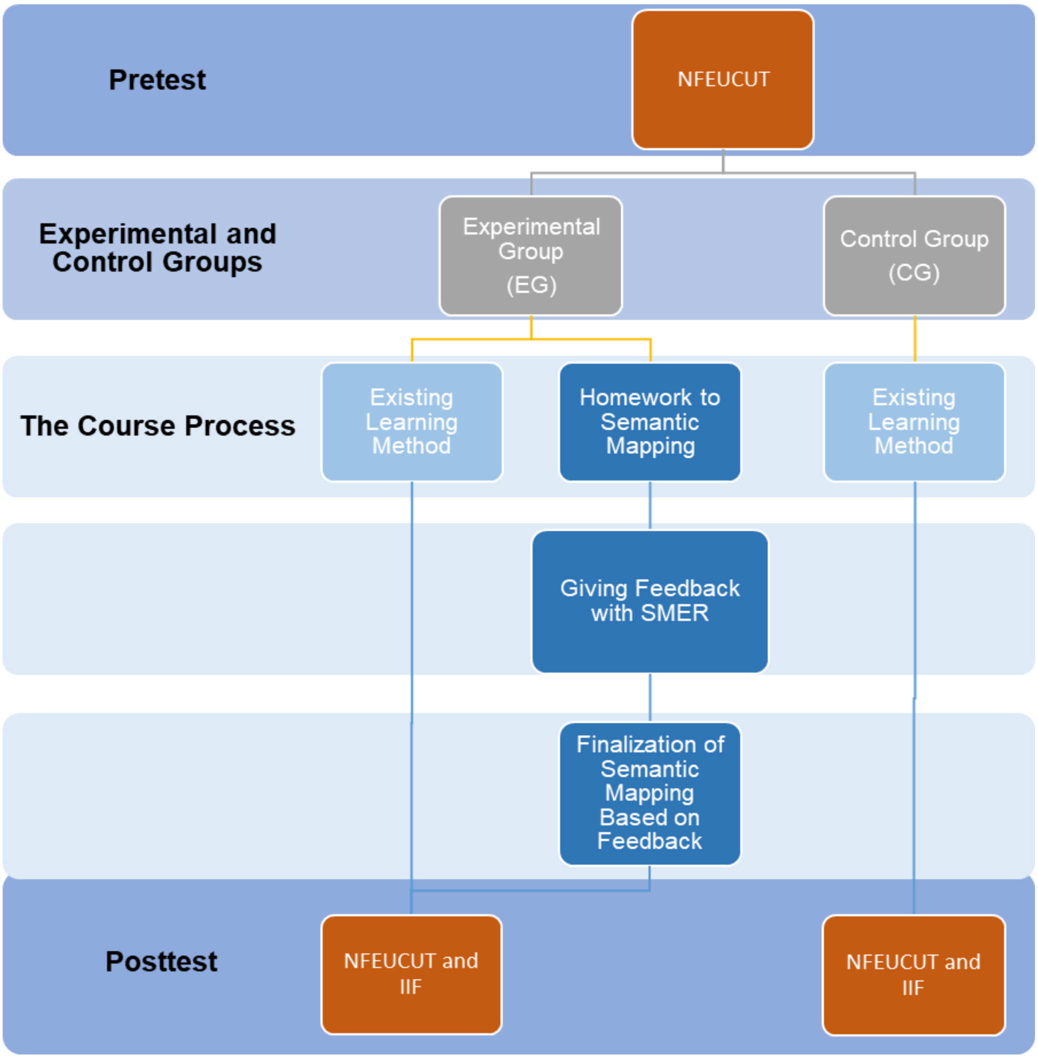


Figure 1. Research design

Data Collection Tools

Before and after the implementation, the students in the experimental and control groups were administered the NFEUCUT, developed by Özden (2019) within the scope of the science curriculum; the SMER, developed by

Zorlu and Zorlu (2020); and the IIF, prepared by using the researchers' observations during the research process.

New Force and Energy Unit Conceptual Understanding Test (NFEUCUT)

Özden's (2019) NFEUCUT comprises 17 multiple-choice questions. The Kuder-Richardson 20 (KR-20) reliability coefficient was determined to be 0.81. The questions constitute three stages to identify the existing misconceptions. The first phase evaluates the student's competence based on their answers (P1 score type: This involves evaluating the answer to the first stage of the question by giving 1 and 0 points). The second phase measures the reason for the answers given to the first question (P2 score type: If both questions are answered correctly, 1 point is awarded, while other answers receive 0 points). The third stage measures whether students are confident in their answers (P3 score type: when the correct answer and the certain option are marked in both stages, it is evaluated as 1 point, while other answers are evaluated as 0 points). Within the scope of this study, the KR-20 reliability coefficient of the NFEUCUT was 0.83.

Semantic Mapping Evaluation Rubric (SMER)

Zorlu and Zorlu's (2020) SMER within the scope of their study was organized and developed as five items: "Key Concepts," "Key Groups," "Eligibility of Groups by Key Concepts," "Concepts Other Than Key Concepts," and "Highlighting What is Important From Groups in Creating a Concept Network." Each item was allocated 5 points. On the scale, one item was scored according to the number of concepts, while the other items were scored according to the percentage of concepts (Table 1).

Table 1. Semantic mapping evaluation rubric (SMER)

Items	5 points	4 points	3 points	2 points	1 points
Key Concepts	%100-81	%80-61	%60-41	%40-21	%20-1
Key Groups	%100-81	%80-61	%60-41	%40-21	%20-1
Eligibility of Groups by Key Concepts	%100-81	%80-61	%60-41	%40-21	%20-1
Concepts Other Than Key Concepts	…-21 Concept	20-16 Concept	15-11 Concept	10-6 Concept	5-1 Concept
Highlighting What is Important From Groups to Creating a Concept Network	%100-81	%80-61	%60-41	%40-21	%20-1

Implementation Interview Form (IIF)

The researchers used the IIF, comprising three open-ended questions, to obtain the opinions of the students participating in the study. The researchers created and used the questions to determine the students' perceptions about the positive and negative aspects, as well as suggestions concerning the semantic mapping activities applied in the teaching of the "Force and Energy" unit.

Implementation Process

Implementation Process in the Experimental Group

The research process started with the application of the form indicating that the students participated in the study voluntarily. At the beginning of the research process, randomly selected experimental group students were administered the NFEUCUT as a pretest before any research-based study occurred to reveal their existing knowledge about the "Force and Energy" unit. The data obtained as a result of the pretest was kept on record. Then, the experimental group students received information about the implementation process and semantic mapping, and sample semantic maps were introduced. After the experimental group students received sufficient knowledge about semantic mapping, the study implementation started. The "Force and Energy" unit comprises three subtopics, and the same study steps were carried out for each subtopic. The first subtopic, "Mass and Weight Relationship," was completed in accordance with the course process. The relationship between mass and weight was examined using a dynamometer and an equal-arm scale. Elaborations were made on the subject by giving examples from daily life, and finally, the process was completed using measurement and evaluation tools. At the end of the topic, teachers asked students to prepare a semantic map within the scope of this subtopic. Students were given sufficient time to prepare their semantic maps and were asked to submit their maps by the deadline. The submitted semantic maps were analyzed and scored with the help of SMER, and then students received feedback. The students finalized their semantic maps by making corrections within the specified time period in line with the feedback given, and the semantic maps were evaluated again using SMER and their final scores were determined. The data obtained was recorded. The other two subtopics of the “Force and Energy” unit were covered similarly. At the end of the implementation process, the NFEUCUT was administered to the experimental group students as a posttest, and the results were recorded. To reveal the thoughts of the participant experimental group students about the implementation process, the IIF was administered. The results of the IIF were evaluated, and the data were recorded.

Implementation Process in the Control Group

The research process started with the application of the form indicating that the students participated in the study voluntarily. At the beginning of the research process, randomly selected control group students were administered the NFEUCUT as a pretest before any research-based study to reveal their existing knowledge about the “Force and Energy” unit. The data obtained as a result of the pretest was kept on record. The other two subtopics of the “Force and Energy” unit were covered similarly. The “Force and Energy” unit comprises three subtopics, and the lesson processes were conducted in each subtopic in accordance with the science curriculum and achievements. The first subtopic, “Mass and Weight Relationship,” was completed in accordance with the course process. The relationship between mass and weight was examined using a dynamometer and an equal-arm scale. The teacher elaborated on the subject by giving examples from daily life, and finally, the process was completed using measurement and evaluation tools. The other two subtopics of the “Force and Energy” unit were covered similarly. At the end of the unit, the NFEUCUT was administered as a posttest. After the posttest, students were given information about semantic mapping, and sample concept networks were introduced. After the students learned about semantic mapping, they were asked to create a semantic map related to the “Force and Energy” unit. After collecting the semantic maps, the maps prepared by the students in the control group were evaluated and scored, and the students received feedback accordingly.

Data Analysis

The researchers analyzed the quantitative data obtained in the study with the SPSS program’s descriptive and predictive statistical methods. They analyzed the qualitative data obtained through the content analysis method. The research products are the concept networks prepared by 27 students in the experimental group for three subtopics within the “Force and Energy” unit. Each semantic map received feedback, and the semantic maps were re-evaluated based on the feedback given. The evaluation was made using SMER, prepared by paying attention to the general features of the semantic mapping implementation. The quantitative data obtained from the P1 and P3 score types of the NFEUCUT were analyzed using normality tests and descriptive and predictive statistical analyses. The data obtained from the IIF were analyzed using the content analysis method within the scope of qualitative data analysis. The process continued by determining themes and codes. The themes and codes obtained were evaluated in terms of percentage and frequency.

Results

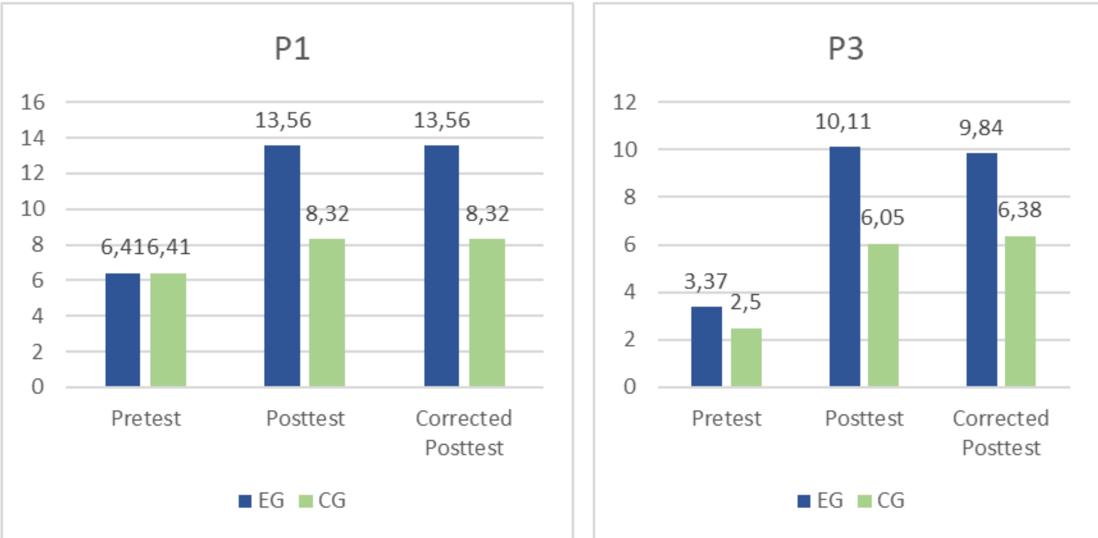
The students in the experimental and control groups were administered the NFEUCUT as a pretest and posttest. As the NFEUCUT comprises a three-stage question type, P1 and P3 scores were used in the study.

Table 2. Descriptive values and normality table according to NFEUCUT P1 and P3 score types

Score Types		Groups	X	Median	Mode	Ranj	Skewness	Skewness Standard Error	Kurtosis	Kurtosis Standard Error
P1	Pretest	EG	6.41	6.00	4.00	8.00	0.358	0.448	-0.997	0.872
		CG	6.41	6.50	7.00	6.00	0.176	0.491	-0.298	0.953
	Posttest	EG	13.56	13.00	12.00	7.00	0.348	0.448	-0.235	0.872
		CG	8.32	8.50	10.00	10.00	-0.179	0.491	-0.995	0.953
P3	Pretest	EG	3.37	3.00	2.00	7.00	0.476	0.448	-0.933	0.872
		CG	2.50	2.50	3.00	6.00	0.626	0.491	0.060	0.953
	Posttest	EG	10.11	11.00	11.00	15.00	-0.210	0.448	0.492	0.872
		CG	6.05	5.50	5.00	9.00	0.379	0.491	-0.886	0.953

The skewness and kurtosis values of the pretest and posttest data of the NFEUCUT P1 and P3 score types were between −1 and +1, and the ratio of skewness value/skewness standard error and kurtosis value/kurtosis standard error was between −1.96 and +1.96 (Table 2). Skewness and kurtosis values between −1 and +1

(Morgan, Leech, Gloeciner & Barret, 2004) and skewness value/skewness standard error and kurtosis value/kurtosis standard error ratios between −1.96 and +1.96 (Can, 2014) indicate that the data distribution is normal. Additionally, researchers conducted a Shapiro-Wilk analysis of normality tests. In line with the Shapiro-Wilk analysis, the distribution was normal ($p > 0.05$).
The scores obtained from the posttests of the NFEUCUT P1 and P3 score types applied to the students in the experimental and control groups were correlated, and analysis of covariance (ANCOVA) was performed to determine whether the differences were statistically significant. Graph 1 and Table 3 present the data obtained as a result of the analysis.



Graph 1. Pretest, posttest, and corrected posttest scores of the experimental and control groups

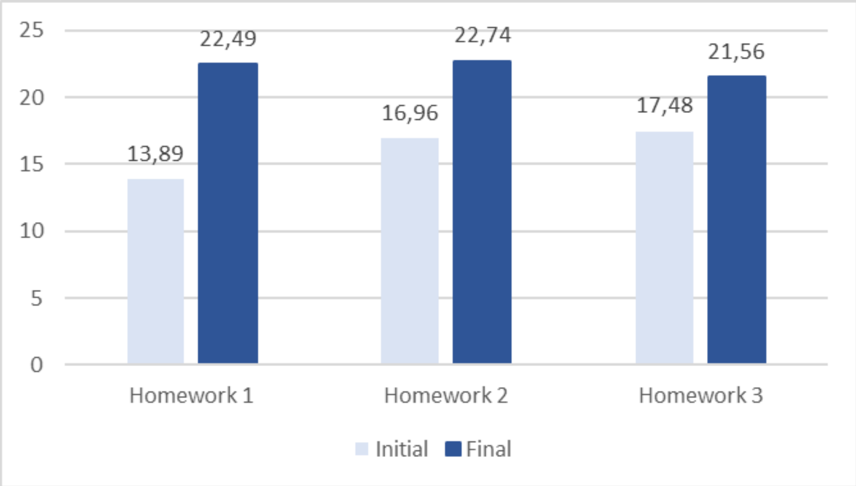
An analysis of Graph 1 suggests that the average posttest scores of the experimental group students are higher than those of the control group students. To understand whether the difference is statistically significant, an ANCOVA analysis was performed on the pretest and posttest results of the NFEUCUT P1 and P3 score types. Table 3 presents the results of the analysis.

Tablo 3. ANCOVA analysis results of NFEUCUT P1 and P3 score types

Source	Sum of Squares	df	Mean of Squares	F	p	η2	Source
P1	NFEUCUT (Pretest)	22.947	1	22.947	3.536	0.066	0.071
	Method	332.589	1	332.589	51.255	**0.000**	0.527
	Error	298.492	46	6.489			
	Total	6805.000	49				
P3	NFEUCUT (Pretest)	92.768	1	92.768	12.520	0.001	0.214
	Method	138.521	1	138.521	18.694	**0.000**	0.289
	Error	340.853	46	7.410			
	Total	3998.000	49				

According to the ANCOVA analysis results in Table 3, there were statistically significant differences between the scores of the students in the experimental and control groups in the NFEUCUT P1 and P3 score types in favor of the experimental group [P1: $F_{(1\text{–}49)} = 51.255$, $p < .05$; P3: $F_{(1\text{–}49)} = 18.694$, $p < .05$]. In line with the applied experimental variable, η2 (eta squared) was found to be 0.527 for the P1 score type and 0.289 for the P3 score type. Approximately 53% of the variance in the posttest scores of the NFEUCUT, which is the dependent variable in the study for the P1 score type, and 29% for the P3 score type, is explained by the implementation process in the experimental and control groups, which are the independent variables.

The three semantic maps prepared by the students in the experimental group were analyzed according to the SMER, and Graph 2 presents the averages of their initial and final scores.



Graph 2. Averages of initial and final scores of semantic mapping homework according to SMER

An examination of Graph 2 reveals that the experimental group students had lower mean scores in the first form of the first semantic map. In the first state of the second and third semantic maps, the mean scores were close to each other and higher than the first semantic map's mean score. The mean scores of the final version of the three semantic maps are close to each other. Table 4 presents the frequency distribution of the initial and final forms of all three semantic maps.

Table 4. Frequency distribution of the initial and final forms of all three semantic maps

	Homework 1				Homework 2				Homework 3			
	Initial		Final		Initial		Final		Initial		Final	
Score Range	f	%	f	%	f	%	f	%	f	%	f	%
0-5	3	11.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
6-10	6	22.2	0	0.0	3	11.1	0	0.0	1	3.7	0	0.0
11-15	6	22.2	0	0.0	6	22.2	1	3.7	2	7.4	0	0.0
16-20	7	25.9	5	18.5	7	25.9	2	7.4	17	63.0	7	25.9
21-25	5	18.6	22	81.5	11	40.8	24	88.9	7	25.9	20	74.1
Total	27	100.0	27	100.0	27	100.0	27	100.0	27	100.0	27	100.0

Table 4 indicates that the experimental group students only had assignments that scored between 0–5 points in the first state of the first semantic map assignment. In the first cases of the semantic mapping assignments, the third assignment (f = 24, 88.9%) was the most common assignment between 16 and 25 points, while the first assignment (f = 12, 44.5%) was the least common assignment. In the final versions of the semantic mapping assignments, there was only one assignment (3.7%) between 0–15 points in the second semantic mapping assignment, while there was no assignment between this score in the other two semantic mapping assignments. According to the observations, 74.1%–88.9% of the final versions of the semantic mapping assignments were between 21–25 points. Sample semantic maps prepared by the students are given in the appendix.

Table 5. Positive aspects of the semantic mapping practice

Positive Aspects	f	%
Reinforcement of the learned subject	14	29.2
Ensuring better learning of the subject	13	27.1
Providing ease of understanding	10	20.8
Making the learning process enjoyable	6	12.5
Ensuring the development of classification skills	4	8.3
Developing a sense of responsibility	1	2.1
Total	48	100.0

According to Table 5, semantic mapping helps teach the subject to be learned more easily and effectively. Permanence increases as the information learned is reinforced. As learners actively participate in the process, a more enthusiastic learning environment is created. The following are some sample student statements.

- *I learned the concepts more easily. I learned how to group things, and the concepts I learned became more permanent in my mind.* (Student EG-10)
- *Creating a semantic map was nice and fun. I can keep concepts in mind more easily.* (Student EG-12)

- *Thanks to semantic mapping, I reinforced the information I learned better.* (Student EG-5)
- *It helps me learn easily. It reveals our sense of responsibility.* (Student EG-22)
- *I learned the concepts faster and did not forget them.* (Student EG-2)
- *It made the lesson review fun for us.* (Student EG-1)

Table 6. Negative aspects of the semantic mapping practice

Negative Aspects	f	%
No negative aspects	18	47.4
Exhausting preparation process	8	21.1
Time-consuming	7	18.4
Concepts are hard to find	2	5.3
Difficult to establish an order of importance	1	2.6
Responsibility needs to be taken	1	2.6
Does not provide detailed information	1	2.6
Total	38	100.0

According to Table 6, most students who participated in the implementation process had positive opinions about the practice. Negative perceptions about the implementation were that the process was tiring and time-consuming owing to the need to take responsibility. There were comments that semantic mapping did not provide detailed information and that there should be some changes during the implementation. The following are some sample student statements.

- *In my opinion, there is no negative aspect of semantic mapping because it helps us learn.* (Student EG-26)
- *It takes me a lot of time to create a semantic map.* (Student EG-8)
- *Creating a semantic map is very laborious, and I get tired.* (Student EG-22)
- *It is very difficult to find the concepts.* (Student EG-3)
- *Making groups in order of importance is a negative aspect.* (Student EG-9)
- *It is necessary to take responsibility.* (Student EG-5)
- *Semantic mapping does not give us much information.* (Student EG-6)

Table 7. Recommendations for the semantic mapping implementation

Recommendations	f	%
No suggestion.	17	43.6
There should be no list of key concepts.	6	15.4
The teacher can provide key concepts.	4	10.3
Explanations for concepts can be added.	4	10.3
Areas of use can be expanded.	3	7.7
Evaluation questions can be asked after the implementation.	2	5.1
The order of importance may not be specified.	1	2.6
The list of key concepts can change places with the semantic map.	1	2.6
Key concepts can be written directly without grouping.	1	2.6
Total	39	100.0

According to Table 7, 44% of the students who participated in the implementation found it to be sufficient and did not feel the need for improvement. Suggestions for improvement from other students were that there should not be a step to list concepts at the beginning of the semantic mapping process or that concepts should be given when the teacher finds them. Suggestions such as including the definitions of these concepts instead of using only concepts in semantic maps, not ranking or grouping concepts, and asking end-of-term assessment questions also appeared in the results. The following are some sample student statements.

- *After our semantic mapping practice, we should ask each other questions to understand what we have learned.* (Student EG-1)
- *The step of listing key concepts can be removed from the practice.* (Student EG-22)
- *We can give the definitions of the concepts we specified in the semantic map.* (Student EG-14)
- *Our teacher could have prepared the concepts themselves and given them to us.* (Student EG-4)
- *Everyone should apply it, and its use should be widespread.* (Student EG-1)
- *It was not important to list the concepts found in the semantic map; instead, we could have written the definitions of the concepts by grouping them without considering their degree of importance.* (Student EG-15)

– *It would be better if we prepared the semantic map concepts, wrote them at the top, and then did the next step of creating groups underneath that.* (Student EG-10)

Conclusion and Discussion

A modern educational approach is necessary for science education to progress dynamically on the path of science (Öztürk, 2019). In contrast to current teaching, the contemporary teaching approach, which includes various learning models, methods, and techniques in the process, forms the basis of the general objectives of the science curriculum updated in 2018 (MoNE, 2018). Based on the results obtained in the literature on semantic maps, the aim was to develop a conceptual understanding of the seventh grade "Force and Energy" unit through semantic mapping within the study framework. In line with this purpose, the findings section demonstrates the results of the information obtained in this study and their association with the literature.

Research on Semantic Maps for Conceptual Understanding in the Seventh Grade "Force and Energy" Unit

The study findings determined that the semantic mapping practice, applied to improve the conceptual understanding of the seventh grade middle school students focused on the concepts within the scope of the "Force and Energy" unit, had positive effects on the students. The study results are consistent with the results of prior studies in that the experimental groups wherein semantic mapping was applied during the teaching process were academically ahead of the control groups that continued with the current teaching method (Aktepe, Cepheci, Irmak & Palaz, 2017; Badr & Abu-Ayyash, 2019; Barut, 2020; Büyüktokatlı, 2009; Dilek & Yürük, 2013; Engür, 2006; Epstein, 1988; Günhan, 2009; Gürlek & Demirkuş, 2020; Jillfitzgerald, Elmore, Kung & Jacson, 2017; MacBeath & Turner, 1990; Reza & Azizah, 2019; Sinan, 2007; Tuna, 2013). Literature reviews indicate that semantic mapping supports current and alternative learning and facilitates effective learning by establishing a relationship between them (Badr & Abu-Ayyash, 2019; Engür, 2006; Heimlich & Pittelman, 1986; Turgut, 1990); moreover, it was observed that the retention of information learned increases in individuals who learn effectively (Zorlu & Sezek, 2016). Students who experience a sense of effective learning have positive attitudes (Erdem, 2019). Active student participation, expressing the desire to learn, fosters increased interaction between teachers and students (Erciyeş, 2010), ensuring that the entire subject is covered (Gürlek & Demirkuş, 2020).

The difficulties of concept teaching in science are noteworthy. In this regard, using semantic mapping for effective concept teaching is recommended (Barut, 2020; Engür, 2006; Gürlek & Demirkuş, 2020; Heimlich & Pittelman, 1986; McIntosh, 1995; Patrizi, Ice, & Burgess, 2013). The fact that one can use it at different stages of the teaching process is seen as an advantage of semantic mapping. Using semantic mapping as homework in these various teaching processes draws attention (Engür, 2006). Studies in the literature show that desired behaviors are formed as a result of using semantic mapping as a homework activity (Engür, 2006; Erdem, 2019; Gürlek & Demirkuş, 2020; Turgut, 1990). For example, students gain self-regulation skills through feedback and correction (Erdem, 2019) and expand and develop concepts in their minds as a result of associating existing knowledge with alternative knowledge (Gürlek & Demirkuş, 2020); furthermore, they develop a sense of responsibility, a thorough, effective, and planned use of time, and individual study skills (Engür, 2006; Erdem, 2019; Turgut, 1990). Owing to the semantic mapping practice, students actively participate in the process and develop positive attitudes toward learning with an increase in the quality of teaching (Dilek &Yürük, 2013; Erciyeş, 2010). The preparation of semantic maps is a student-specific, subjective process; therefore, researchers recommend preparing a separate evaluation rubric for each student (Gürlek & Demirkuş, 2020). With timely feedback, students will not acquire information incorrectly and will correct their existing mislearning (Uysal, 2016). Our conclusion that the concepts in the "Force and Energy" unit provide meaningful learning by effectively implementing semantic mapping as homework without causing problems in terms of time and cost if the process is planned and maintained from the beginning and by giving individual feedback with the correct evaluation scale is in line with the results of the literature (Bilen, 1999).

Seventh Grade Students' Views on the Semantic Mapping Practice

The results of the structured interview form to obtain the views of the seventh grade students participating in this study on the semantic mapping practice indicate that the students reinforced the subject, demonstrating more effective learning. Another result revealed that students had more fun and were more enthusiastic as they actively participated in the process. The effectiveness of teaching increases with active participation in the learning process, and therefore, the importance of using semantic mapping emerges. Most students who participated in the application stated that they did not have negative perceptions about semantic mapping.

According to the students’ opinions, the negative aspect of the semantic mapping practice was that it was time-consuming and labor-intensive. For this reason, they generally found the implementation adequate and did not make suggestions for improvement. The existing negative thoughts reveal the need for students to develop a sense of responsibility. Suggestions for improving the semantic mapping practice were that teachers should provide and list the concepts to be used, that explanations of the concepts should be added, and that there should not be an indication of importance. These suggestions are desirable because they reduce students’ responsibility and are indirectly linked to their negative opinions about semantic mapping. Based on an analysis of the related studies in the literature, previous studies have similar research results, indicating that the subject is learned and reinforced more effectively (Dilek & Yürük, 2013; Ekici, 2014; Günhan, 2009; Jillfitzgerald, Elmore, Kung & Jacson, 2017; Zorlu ve Zorlu, 2020, 2021). The results that semantic maps involve students more actively in the process with the implementation of semantic maps as homework in the experimental group are in parallel with the results in the literature (Aktepe, Cepheci, Irmak, & Palaz, 2017; Badr & Abu-Ayyash, 2019; Demir & Sezek, 2009; Gürlek & Demirkuş, 2020). In this regard, the use of semantic mapping is recommended to achieve effective teaching process outcomes. Additionally, suggestions for improving the implementation process, making the method more widespread, and measuring the information learned with evaluation questions at the end of the implementation are similar to the results of this study (Badr & Abu-Ayyash, 2019; Dilek & Yürük, 2013; Ekici, 2014; Günhan, 2009; Gürlek & Demirkuş, 2020). Based on the results, the process should be supported with evaluation questions at the end of the semantic mapping implementation, and its use should be expanded to different levels and courses.

Recommendations

- Semantic mapping implementation can be planned and executed at different grade levels to explore the impact of different variables.
- In this study, researchers selected the experimental group using simple sampling methods and reached the results on a limited scale. Future research can be conducted by expanding the sample area or in schools with different characteristics.
- Our study results reveal that semantic mapping positively affects student performance and attitudes. From this perspective, the use of semantic mapping in the science education process can be expanded.
- Our study results show that semantic mapping influences meaningful conceptual learning and, thus, academic achievement. To popularize its use, informative seminars can be given to educators about semantic mapping.

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Author (s) Contribution Rate

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Conflicts of Interest

There aren't any potential conflicts of interest.

Ethical Approval (only for necessary papers)

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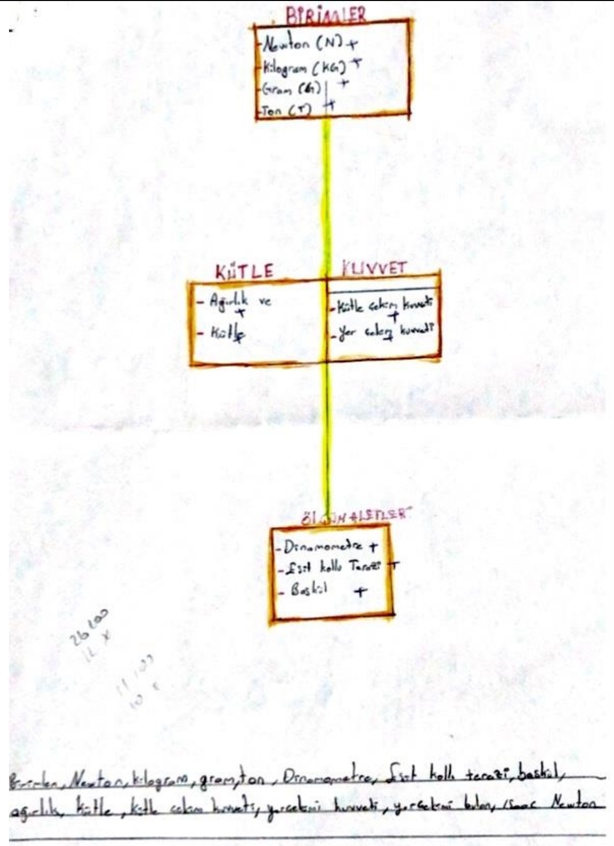
Appendix: Samples of the experimental group students' semantic mappings are given below.

<table>
<tr><th>Initial</th><th>Final</th></tr>
<tr><td>


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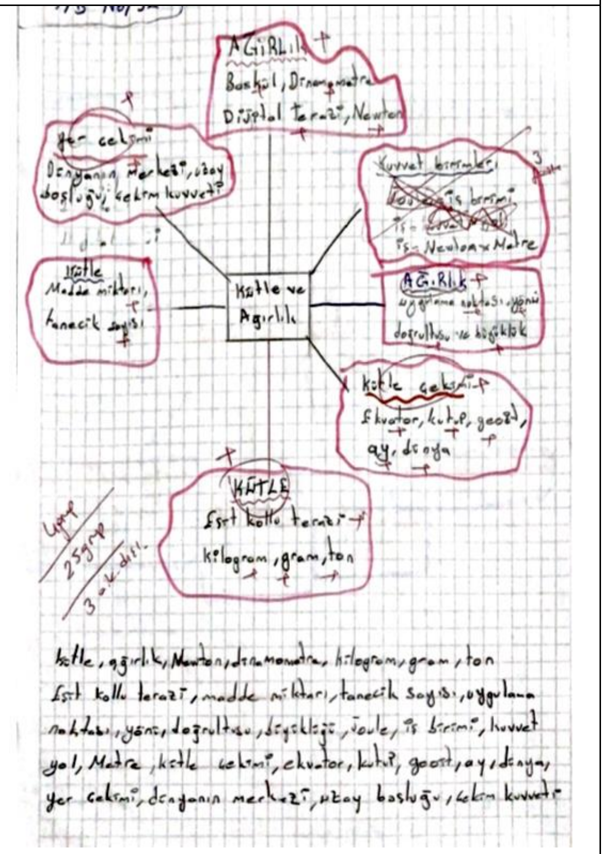
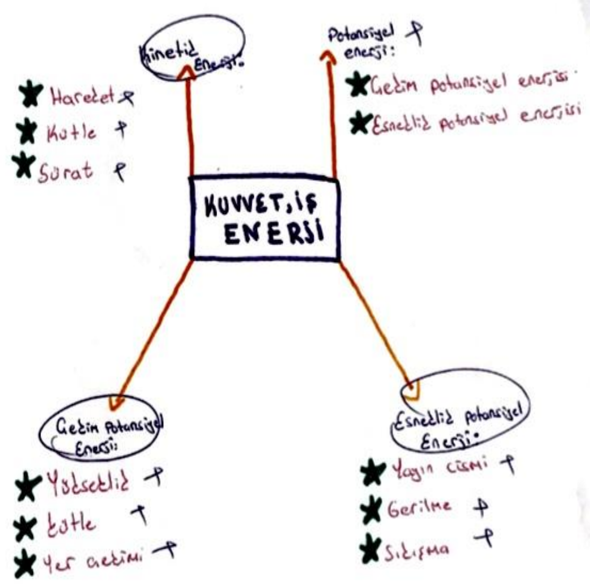
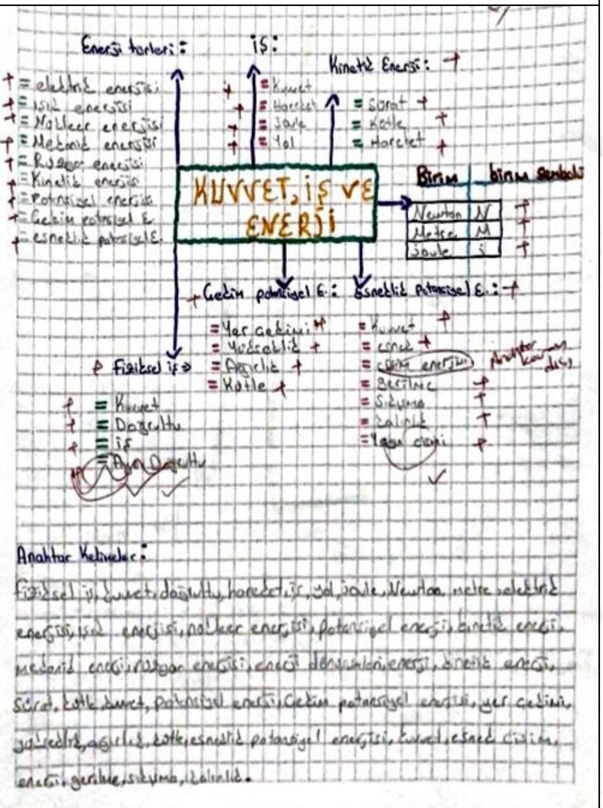
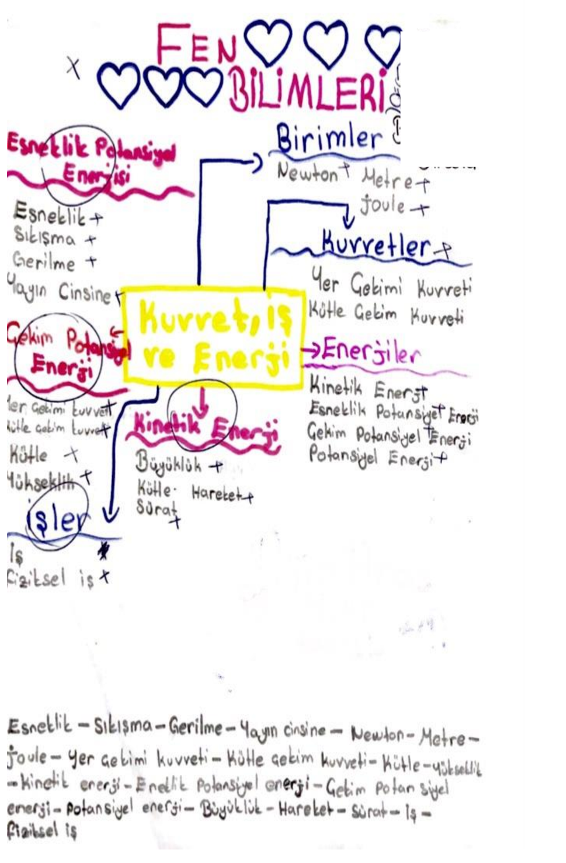
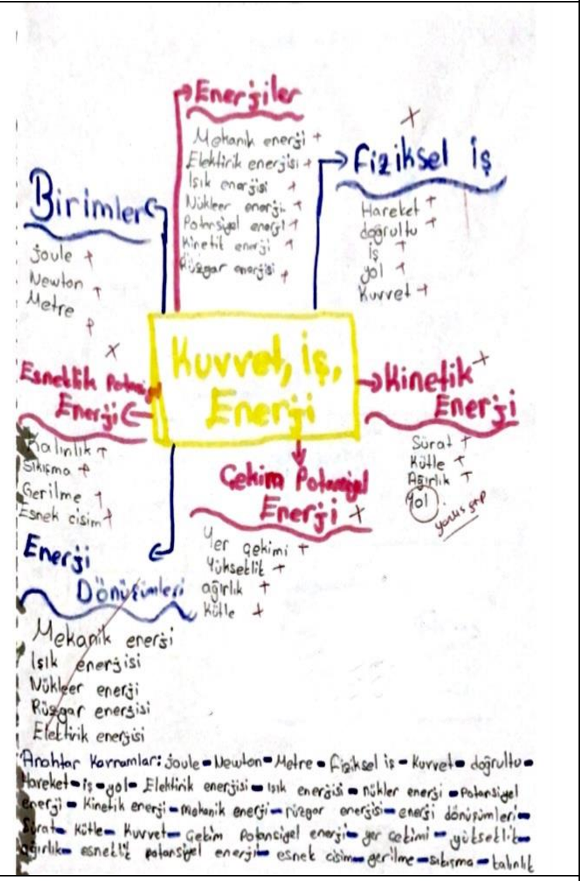


</td></tr>
<tr><td>
* Anahtar kavramlar: 26 anahtar kavram var. Öğrenci 11 tane kullanmıştır. %42 5 puan
* Anahtar Gruplar: 4 anahtar grup vardır. Öğrenci 1 tane kullanmıştır. %25 2 puan
* İçerdiği kavramlara göre grupların uygunluğu: kullanılan 11 kavramdan 1 tanesi gruba uygun değildir. %90 5 puan
* anahtar kavram dışındaki kavramlar: anahtar kavram dışında kavram kullanılmamıştır. %100 5 puan
* kavram ağı oluşturmada gruplardan önemli olanlara vurgulama: Önem vurgusu vardır. %100 5 puan
* PUAN: 20/25 puan üzerinden değerlendirilmiştir.
* DÖNÜT AÇIKLAMASI ÖNERİ:
1. Mutlaka kullanılması gereken anahtar kavramlar "kütle, madde miktarı, tanecik sayısı, kg, g, t, eşit kollu terazi, ağırlık, newton, dinamometre, baskül, dijital terazi, yer çekimi kuvveti, kuvvet, uygulama noktası, yön, doğrultu, büyüklük, kütle çekimi, dünya merkezi, uzay boşluğu, ay, dünya, ekvator, kutup, geoit"
2. 4 ana grup mutlaka olmalı "kütle, ağırlık, yer çekimi, kütle çekimi".
3. Oluşturduğun gruplarda kavramlar grup ile uyumlu olmalıdır. Kütle adı altında oluşturduğun grupta ağırlık olmaz. Silmelisin.
4. Anahtar kavramlar dışında kavram kullanılmamalıdır. Anahtar kavramlar birinci öneride verilmiştir.
5. Oluşturduğun gruplar ana kavrama göre yakın veya uzak olmalıdır. Önem derecesine göre yakından uzağa doğru gruplar sıralanmalıdır.
</td><td>
Anahtar Kavramlar: 26 kavram kullanılmalıdır. Öğrenci 25 tane kullanmıştır. 5 puan.
Anahtar Gruplar: 4 grup oluşturulmalıdır. Öğrenci hepsini oluşturmuştur. 5 puan.
İçerdiği Kavramlara Göre Grupların Uygunluğu: Kullanılan kavramlar gruplara uygundur. 5 puan.
Anahtar Kavram Dışındaki Kavramlar: Anahtar kavram dışında 3 kavram vardır. 5 puan.
Kavram Ağı Oluşturmada Gruplardan Önemli Olanlara Vurgu: Önem vurgusu vardır. 5 puan.

Puan: 25 puan.

Dönüt Açıklaması:
1. Mutlaka kullanılması gerekilen kavramlar 'Kütle, Madde Miktarı, Tanecik Sayısı, Kg, g, t, Eşit Kollu Terazi, Ağırlık, Dinamometre, Baskül, Dijital Terazi, Yer Çekimi, Kuvvet, Uygulama Noktası, Yön, Doğrultu, Büyüklük, Kütle Çekimi, Dünya Merkezi, Uzay Boşluğu, Ay, Dünya, Ekvator, Kutup, Geoit '.
2. Mutlaka kullanılması gereken 4 grup olmalıdır. Bunlar 'Kütle, Ağırlık, Yer Çekimi, Kütle Çekimi'.
3. Kullanılan kavramlar gruplara uygun olmalıdır.
4. Birinci öneride verilen kavramlar haricinde kavram kullanılmamalıdır.
5. Oluşturulan gruplar ana kavrama yakınlık uzaklık bakımından önem derecesine göre oluşturulmalıdır.
</td></tr>
</table>

Initial	Final
	
Anahtar Kavramlar: 35 kavram kullanılmalıdır. Öğrenci 13 tane kullanmıştır. 2 puan. **Anahtar Gruplar:** 4 grup oluşturulmalıdır. Öğrenci 3 tane oluşturmuştur. 4 puan. **İçerdiği Kavramlara Göre Grupların Uygunluğu:** Kullanılan kavramlar gruplara uygundur. 5 puan. **Anahtar Kavram Dışındaki Kavramlar:** Anahtar kavram dışında kavram yoktur. 5 puan. **Kavram Ağı Oluşturmada Gruplardan Önemli Olanlara Vurgu:** Önem vurgusu yoktur. 0 puan. **Puan:** 16 puan. **Dönüt Açıklaması:** 1. Mutlaka kullanılması gerekilen kavramlar 'Fiziksel iş, kuvvet, doğrultu, hareket, iş, yol, joule, Newton, metre, elektrik enerjisi, ışık enerjisi, nükleer enerji, potansiyel enerji, kinetik enerji, mekanik enerji, rüzgâr enerjisi, enerji dönüşümleri, enerji, kinetik enerji, sürat, kütle, kuvvet, potansiyel enerji, çekim potansiyel enerjisi, yer çekimi, yükseklik, ağırlık, kütle, esneklik potansiyel enerjisi, kuvvet, esnek cisim, enerji, gerilme, sıkışma, kalınlık'. 2. Mutlaka kullanılması gereken 4 grup olmalıdır. Bunlar ' Fiziksel iş, Kinetik Enerji, Çekim Potansiyel Enerjisi, Esneklik Potansiyel Enerjisi'. 3. Kullanılan kavramlar gruplara uygun olmalıdır. 4. Birinci öneride verilen kavramlar haricinde kavram kullanılmamalıdır. 5. Oluşturulan gruplar ana kavrama yakınlık uzaklık bakımından önem derecesine göre oluşturulmalıdır.	**Anahtar Kavramlar:** 35 kavram kullanılmalıdır. Öğrenci 35 tane kullanmıştır. 5 Puan **Anahtar Gruplar:** 4 grup oluşturulmalıdır. Öğrenci 4 tane oluşturmuştur. 5 puan. **İçerdiği Kavramlara Göre Grupların Uygunluğu:** Kullanılan kavramlar gruba uygundur. 5 puan. **Anahtar Kavram Dışındaki Kavramlar:** Anahtar kavram dışında 1 tane kavram vardır. 5 puan. **Kavram Ağı Oluşturmada Gruplardan Önemli Olanlara Vurgu:** Önem vurgusu vardır. 5 puan. **Puan:** 25 puan. **Dönüt Açıklaması:** 1. Mutlaka kullanılması gerekilen kavramlar 'Fiziksel iş, kuvvet, doğrultu, hareket, iş, yol, joule, Newton, metre, elektrik enerjisi, ışık enerjisi, nükleer enerji, potansiyel enerji, kinetik enerji, mekanik enerji, rüzgâr enerjisi, enerji dönüşümleri, enerji, kinetik enerji, sürat, kütle, kuvvet, potansiyel enerji, çekim potansiyel enerjisi, yer çekimi, yükseklik, ağırlık, kütle, esneklik potansiyel enerjisi, kuvvet, esnek cisim, enerji, gerilme, sıkışma, kalınlık'. 2. Mutlaka kullanılması gereken 4 grup olmalıdır. Bunlar ' Fiziksel iş, Kinetik Enerji, Çekim Potansiyel Enerjisi, Esneklik Potansiyel Enerjisi'. 3. Kullanılan kavramlar gruplara uygun olmalıdır. 4. Birinci öneride verilen kavramlar haricinde kavram kullanılmamalıdır. Cisim enerjisi anahtar kavram değildir. 5. Oluşturulan gruplar ana kavrama yakınlık uzaklık bakımından önem derecesine göre oluşturulmalıdır.

Initial	Final
	

Initial

Anahtar Kavramlar: 35 kavram kullanılmalıdır. Öğrenci 20 tane kullanmıştır. 3 Puan
Anahtar Gruplar: 4 grup oluşturulmalıdır. Öğrenci hepsini oluşturmuştur. 5 puan.
İçerdiği Kavramlara Göre Grupların Uygunluğu: Kullanılan kavramlar gruplara uygundur. 5 puan.
Anahtar Kavram Dışındaki Kavramlar: Anahtar kavram dışında kavram yoktur. 5 puan.
Kavram Ağı Oluşturmada Gruplardan Önemli Olanlara Vurgu: Önem vurgusu vardır. 5 puan.

Puan: 23 puan.

Dönüt Açıklaması:

1. Mutlaka kullanılması gerekilen kavramlar 'Fiziksel iş, kuvvet, doğrultu, hareket, iş, yol, joule, Newton, metre, elektrik enerjisi, ışık enerjisi, nükleer enerji, potansiyel enerji, kinetik enerji, mekanik enerji, rüzgâr enerjisi, enerji dönüşümleri, enerji, kinetik enerji, sürat, kütle, kuvvet, potansiyel enerji, çekim potansiyel enerjisi, yer çekimi, yükseklik, ağırlık, kütle, esneklik potansiyel enerjisi, kuvvet, esnek cisim, enerji, gerilme, sıkışma, kalınlık'.
2. Mutlaka kullanılması gereken 4 grup olmalıdır. Bunlar ' Fiziksel iş, Kinetik Enerji, Çekim Potansiyel Enerjisi, Esneklik Potansiyel Enerjisi'.
3. Kullanılan kavramlar gruplara uygun olmalıdır.
4. Birinci öneride verilen kavramlar haricinde kavram kullanılmamalıdır.
5. Oluşturulan gruplar ana kavrama yakınlık uzaklık bakımından önem derecesine göre oluşturulmalıdır.

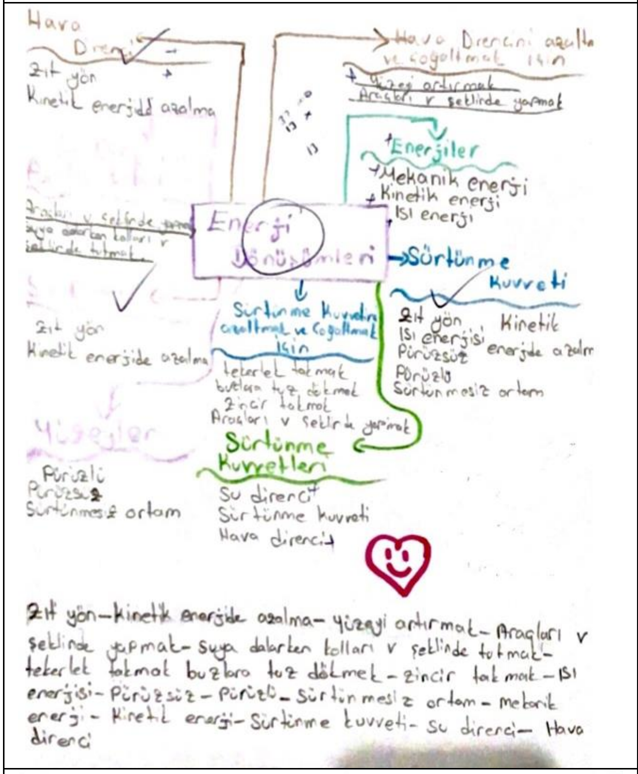
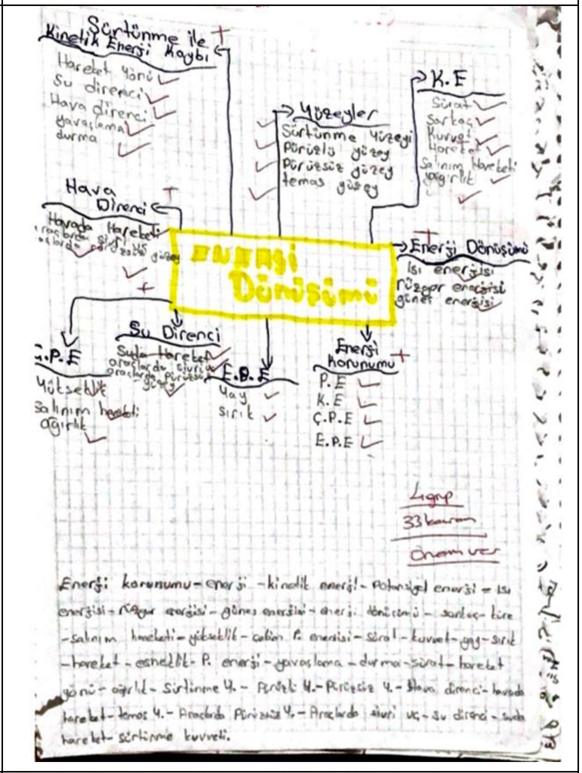
Final

Anahtar Kavramlar: 35 kavram kullanılmalıdır. Öğrenci 30 tane kullanmıştır. 5 Puan
Anahtar Gruplar: 4 grup oluşturulmalıdır. Öğrenci hepsini oluşturmuştur. 5 puan.
İçerdiği Kavramlara Göre Grupların Uygunluğu: Kullanılan kavramlardan 1 tanesi gruba uygun değildir. 5 puan.
Anahtar Kavram Dışındaki Kavramlar: Anahtar kavram dışında kavram yoktur. 5 puan.
Kavram Ağı Oluşturmada Gruplardan Önemli Olanlara Vurgu: Önem vurgusu vardır. 5 puan.

Puan: 25 puan.

Dönüt Açıklaması:

1. Mutlaka kullanılması gerekilen kavramlar 'Fiziksel iş, kuvvet, doğrultu, hareket, iş, yol, joule, Newton, metre, elektrik enerjisi, ışık enerjisi, nükleer enerji, potansiyel enerji, kinetik enerji, mekanik enerji, rüzgâr enerjisi, enerji dönüşümleri, enerji, kinetik enerji, sürat, kütle, kuvvet, potansiyel enerji, çekim potansiyel enerjisi, yer çekimi, yükseklik, ağırlık, kütle, esneklik potansiyel enerjisi, kuvvet, esnek cisim, enerji, gerilme, sıkışma, kalınlık'.
2. Mutlaka kullanılması gereken 4 grup olmalıdır. Bunlar ' Fiziksel iş, Kinetik Enerji, Çekim Potansiyel Enerjisi, Esneklik Potansiyel Enerjisi'.
3. Kullanılan kavramlar gruplara uygun olmalıdır. Yol kavramı gruba uygun değildir.
4. Birinci öneride verilen kavramlar haricinde kavram kullanılmamalıdır.
5. Oluşturulan gruplar ana kavrama yakınlık uzaklık bakımından önem derecesine göre oluşturulmalıdır.

Initial	Final
	
Anahtar Kavramlar: 37 kavram kullanılmalıdır. Öğrenci 13 tane kullanmıştır. 2 puan. **Anahtar Gruplar:** 4 grup oluşturulmalıdır. Öğrenci 3 tane oluşturmuştur. 4 puan. **İçerdiği Kavramlara Göre Grupların Uygunluğu:** Kullanılan kavramlar gruplara uygundur. 5 puan. **Anahtar Kavram Dışındaki Kavramlar:** Anahtar kavram dışında kavram yoktur. 5 puan. **Kavram Ağı Oluşturmada Gruplardan Önemli Olanlara Vurgu:** Önem vurgusu vardır. 5 puan. **Puan:** 21 puan. **Dönüt Açıklaması:** **1.Mutlaka kullanılması gerekilen kavramlar 'Enerji korunumu, enerji, kinetik enerji, potansiyel enerji, ısı enerjisi, rüzgâr enerjisi, güneş enerjisi, enerji dönüşümü, sarkaç, küre, salınım hareketi, yükseklik, çekim potansiyel enerjisi, sürat, kuvvet, yükseklik, yay, sırık, hareket, esneklik potansiyel enerji, yavaşlama, durma, sürat, hareket yönü, ağırlık, sürtünme yüzeyi, pürüzlü yüzey, pürüzsüz yüzey, hava direnci, havada hareketi, temas yüzeyi, hareket yönü, araçlarda pürüzsüz yüzey, araçlarda sivri uç, su direnci, suda hareket, sürtünme kuvveti'.** **2. Mutlaka kullanılması gereken 4 grup olmalıdır. Bunlar 'Enerji Korunumu, Enerji Dönüşümü, Sürtünme ile Kinetik Enerji Kaybı, Hava ve Su Direnci'.** **3. Kullanılan kavramlar gruplara uygun olmalıdır.** **4. Birinci öneride verilen kavramlar haricinde kavram kullanılmamalıdır.** **5. Oluşturulan gruplar ana kavrama yakınlık uzaklık bakımından önem derecesine göre oluşturulmalıdır.**	**Anahtar Kavramlar:** 37 kavram kullanılmalıdır. Öğrenci 33 tane kullanmıştır. 5 puan. **Anahtar Gruplar:** 4 grup oluşturulmalıdır. Öğrenci 4 tane oluşturmuştur. 5 puan. **İçerdiği Kavramlara Göre Grupların Uygunluğu:** Kullanılan kavramlar gruba uygundur. 5 puan. **Anahtar Kavram Dışındaki Kavramlar:** Anahtar kavram dışında kavram yoktur. 5 puan. **Kavram Ağı Oluşturmada Gruplardan Önemli Olanlara Vurgu:** Önem vurgusu vardır. 5 puan. **Puan:** 25 puan. **Dönüt Açıklaması:** 1.Mutlaka kullanılması gerekilen kavramlar 'Enerji korunumu, enerji, kinetik enerji, potansiyel enerji, ısı enerjisi, rüzgâr enerjisi, güneş enerjisi, enerji dönüşümü, sarkaç, küre, salınım hareketi, yükseklik, çekim potansiyel enerjisi, sürat, kuvvet, yükseklik, yay, sırık, hareket, esneklik potansiyel enerji, yavaşlama, durma, sürat, hareket yönü, ağırlık, sürtünme yüzeyi, pürüzlü yüzey, pürüzsüz yüzey, hava direnci, havada hareketi, temas yüzeyi, hareket yönü, araçlarda pürüzsüz yüzey, araçlarda sivri uç, su direnci, suda hareket, sürtünme kuvveti'. 2. Mutlaka kullanılması gereken 4 grup olmalıdır. Bunlar 'Enerji Korunumu, Enerji Dönüşümü, Sürtünme ile Kinetik Enerji Kaybı, Hava ve Su Direnci'. 3. Kullanılan kavramlar gruplara uygun olmalıdır. 4. Birinci öneride verilen kavramlar haricinde kavram kullanılmamalıdır. 5. Oluşturulan gruplar ana kavrama yakınlık uzaklık bakımından önem derecesine göre oluşturulmalıdır.

<table>
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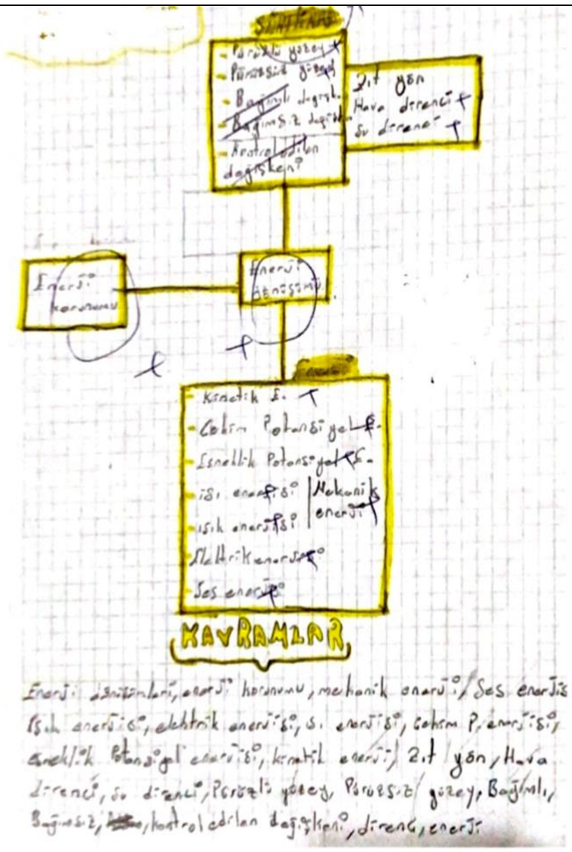
<tr><td></td><td></td></tr>
<tr><td>**Anahtar Kavramlar:** 37 kavram kullanılmalıdır. Öğrenci 15 tane kullanmıştır. 2 puan.
Anahtar Gruplar: 4 grup oluşturulmalıdır. Öğrenci 3 tane oluşturmuştur. 4 puan.
İçerdiği Kavramlara Göre Grupların Uygunluğu: Kullanılan kavramlardan 3 tanesi gruba uygun değildir. 2 puan.
Anahtar Kavram Dışındaki Kavramlar: Anahtar kavram dışında 3 tane kavram vardır. 2 puan.
Kavram Ağı Oluşturmada Gruplardan Önemli Olanlara Vurgu: Önem vurgusu yetersizdir ama vardır. 3 puan.

Puan: 13 puan.

Dönüt Açıklaması:
1.Mutlaka kullanılması gerekilen kavramlar 'Enerji korunumu, enerji, kinetik enerji, potansiyel enerji, ısı enerjisi, rüzgâr enerjisi, güneş enerjisi, enerji dönüşümü, sarkaç, küre, salınım hareketi, yükseklik, çekim potansiyel enerjisi, sürat, kuvvet, yükseklik, yay, sırık, hareket, esneklik potansiyel enerji, yavaşlama, durma, sürat, hareket yönü, ağırlık, sürtünme yüzeyi, pürüzlü yüzey, pürüzsüz yüzey, hava direnci, havada hareketi, temas yüzeyi, hareket yönü, araçlarda pürüzsüz yüzey, araçlarda sivri uç, su direnci, suda hareket, sürtünme kuvveti'.
2. Mutlaka kullanılması gereken 4 grup olmalıdır. Bunlar 'Enerji Korunumu, Enerji Dönüşümü, Sürtünme ile Kinetik Enerji Kaybı, Hava ve Su Direnci'.
3. Kullanılan kavramlar gruplara uygun olmalıdır. Bağımlı, bağımsız, kontrol edilen değişken kavramları gruba uyun değildir.
4. Birinci öneride verilen kavramlar haricinde kavram kullanılmamalıdır. Bağımlı, bağımsız, kontrol edilen değişken kavramları anahtar kavram dışındadır.
5. Oluşturulan gruplar ana kavrama yakınlık uzaklık bakımından önem derecesine göre oluşturulmalıdır.</td><td>**Anahtar Kavramlar:** 37 kavram kullanılmalıdır. Öğrenci 31 tane kullanmıştır. 5 puan.
Anahtar Gruplar: 4 grup oluşturulmalıdır. Öğrenci 4 tane oluşturmuştur. 5 puan.
İçerdiği Kavramlara Göre Grupların Uygunluğu: Kullanılan kavramlardan 4 tanesi gruba uygun değildir. 5 puan.
Anahtar Kavram Dışındaki Kavramlar: Anahtar kavram dışında kavram yoktur. 5 puan.
Kavram Ağı Oluşturmada Gruplardan Önemli Olanlara Vurgu: Önem vurgusu vardır. 5 puan.

Puan: 25 puan.

Dönüt Açıklaması:
1.Mutlaka kullanılması gerekilen kavramlar 'Enerji korunumu, enerji, kinetik enerji, potansiyel enerji, ısı enerjisi, rüzgâr enerjisi, güneş enerjisi, enerji dönüşümü, sarkaç, küre, salınım hareketi, yükseklik, çekim potansiyel enerjisi, sürat, kuvvet, yükseklik, yay, sırık, hareket, esneklik potansiyel enerji, yavaşlama, durma, sürat, hareket yönü, ağırlık, sürtünme yüzeyi, pürüzlü yüzey, pürüzsüz yüzey, hava direnci, havada hareketi, temas yüzeyi, hareket yönü, araçlarda pürüzsüz yüzey, araçlarda sivri uç, su direnci, suda hareket, sürtünme kuvveti'.
2. Mutlaka kullanılması gereken 4 grup olmalıdır. Bunlar 'Enerji Korunumu, Enerji Dönüşümü, Sürtünme ile Kinetik Enerji Kaybı, Hava ve Su Direnci'.
3. Kullanılan kavramlar gruplara uygun olmalıdır. Sarkaç, küre, yay, sırık kavramları gruba uygun değildir.
4. Birinci öneride verilen kavramlar haricinde kavram kullanılmamalıdır.
5. Oluşturulan gruplar ana kavrama yakınlık uzaklık bakımından önem derecesine göre oluşturulmalıdır.</td></tr>
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