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Influence of Computer-Assisted Roundhouse Diagrams on High School 9th Grade Students' Understanding the Subjects of "Force and Motion"*

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ABSTRACT: Main aim of this study is to examine the influence of computer-assisted roundhouse diagrams on high school 9th grade students' academic achievements in the subjects of "Force and Motion". The study was carried out in a public high school in Diyarbakir the province in the Southeast of Turkey. In the study, the "pre-test-post-test control group model", which is among experimental models, was applied. The lessons were taught to the control group students by carrying out the activities previously determined in the curriculum; in other respects, besides these activities, the lessons were taught to the experimental group students by forming roundhouse diagrams that included the subject-related concepts. In the present study focusing on the subjects of "Force and Motion", a multiple-choice achievement test consist of 20 questions related to the subjects of "Force and Motion" was applied as pre-test and post-test to the students to determine the changes in their achievements. The study showed that computer-assisted roundhouse diagrams have significant effect on students' academic achievement in the subjects of "Force and Motion" ($P<0.05$). Besides the multiple-choice test used, another test of 20 fill-in-the-blank and true-false questions was applied as pre-test and post-test in the study. According to the results of this test, the scores of the participants were found high in favour of the experimental group ($P<0.05$). In addition to these two tests measuring the academic achievements of the participants, a questionnaire for the experimental group students' views about the roundhouse diagrams was conducted. As a result of the analysis of the data obtained via this scale, it was found out that the students enjoyed studying with the roundhouse diagram and that they considered the roundhouse diagram as a beneficial method in learning concepts.

KEY WORDS: Physics education, computer, roundhouse diagram, force and motion

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* This study had been derived from Kocakaya (2011)'s Master thesis.

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INTRODUCTION

Today, parallel to the rapid developments in science and technology, the needs in the field of education are gradually increasing. Not only authorities determining the educational policies in the country but also educational researchers and practitioner have important responsibilities in providing such educational needs. By observing and talking to students in educational environments, educational researchers and teachers can determine what they could do to help students become active in learning environments. In addition, teachers should not forget that learning depends on our current knowledge; that new ideas are formed as a result of evaluation of older thoughts; and that new thoughts and ideas gain importance as a result of adaptation of our previous ideas (Şems, 2006). The principle in a meaningful learning process is that individuals should give meaning to the knowledge in their own minds. Ausubel (1968) claims that learning should occur meaningfully in order for knowledge to become permanent, memorable and usable in other fields. Novak (1984) states that in meaningful learning, the meaningfulness of associating the new information with the previous knowledge depends on the quality of the cognitive structure of an individual and on the efforts made while establishing connection between concepts. For instance, as there will be no association between the new and previous concepts in rote learning, the current cognitive structure will not be able to be revised, nor will the knowledge be able to be restructured (Akpınar & Ergin, 2007). Today, since studies conducted on learning have different dimensions, as stated by Ayas et. al., (1993) and Novak (1984), the goal is not to memorize concepts but to learn them meaningfully (Tekin et. al., 2004). The same process was also emphasized by Novak and Gowin (1984).

According to its definition, concept refers to the mental structure or representation that represents the organized knowledge of an individual about an object, event, action, quality and relationship (Klausmeier, 1992). If concepts are abstract thoughts as mentioned, then it will be quite difficult for students to envisage these abstract concepts. Teachers have important responsibilities in overcoming this difficulty.

In Turkey, student-centred approaches have been using in elementary schools since the academic year of 2005-2006 and in secondary schools since the academic year of 2008-2009. According to Gilbert (2006), one of the purposes of Context-Based Learning Approach is to increase students' literacy in science. In line with this, in Context-Based Learning Approach, individuals create contexts depending on daily-life experiences and start to learn via this context (Choi & Johnson 2005). Both those supporting socio-cultural learning (Merriam & Caffarella 1999) and those supporting the constructivist learning theory (Jonassen et.al., 1999) claim that learning will be influenced positively via context-based events presented in association with real-world contexts.

In Context-Based Learning Approach, individuals create contexts depending on daily-life experiences and start to learn thanks to these experiences (Choi & Jhonson 2005). One important purpose of context-based approach is to present the physics-related abstract concepts to students by applying them to real life situations. Therefore, in order to achieve meaningful learning in the instructional process, there is a need for instructional techniques and activities that help students adapt either abstract concepts to their real-life experiences or their observations in real life to the concepts learnt. One of these techniques that will help not only give meaning to learning but also structure the knowledge is the “Roundhouse Diagram”, on which there is little research conducted (Bora et. al., 2006). When science-related literature is examined, it is seen that the Roundhouse Diagram was first developed and used by Ward and Wandersee.

Ward and Wandersee (2000), in their study titled ”Roundhouse Diagrams”, investigated the related key concepts necessary for students to learn science and pointed out that students should understand by establishing relationships between systems. In their study, the researchers then introduced the Roundhouse Diagram and explained how to create these diagrams. In another study titled “Visualizing science using the roundhouse diagram”, Ward and Wandersee (2001) stated that in learning science-related subjects, the Roundhouse Diagram is an effective method which allows using the principles of constructivist learning and which helps students understand the Roundhouse Diagram. Therefore, it was pointed out that the Roundhouse Diagram can allow revealing whether students have misunderstood the subjects or not and can help students easily remember what they have learnt without any need for memorization.

In another study, Ward and Wandersee (2002a) investigated the influence of learning via Roundhouse Diagrams on lower-grade students’ understanding science-related concepts and principles. In their study, the researchers aimed at investigating the contributions of Roundhouse Diagrams to students’ meaningful learning of science subjects on the basis of the meta-cognitive visual learning model. Ward and Wandersee, in their study, reported that Roundhouse Diagrams allow students to revise the part-whole relationships found within the information and helped them envisage the newly-learnt information and become creative. In addition, in their case study titled “Students' Perceptions of Roundhouse Diagramming: A Middle-School Viewpoint”, Ward and Wandersee (2002b) examined the effects of creating Roundhouse Diagrams on elementary school 6th grade students’ meaningful learning of science concepts. As a result of their study, the researchers concluded that students understand most science concepts by creating diagrams. A number of other researchers have also found similar results (Hackney & Ward, 2002; Bora et. al., 2006; Ermiş, 2008; Kocakaya, 2011).

Thanks to this design and creation process, the Roundhouse Diagram helps students construct concepts in their minds and reinforce these concepts with the help of their daily-life experiences. Roundhouse Diagrams support the goals of Context-Based Learning Approach in the course of physics (Life-Based Learning) and the curricular activities in physics. Therefore, the present study is believed to be important for revealing the usability of Roundhouse Diagrams in the course of physics. The pieces of texts in the Roundhouse Diagrams used in the study were described and reinforced with daily-life experiences. Therefore, use of computer support in class environment will play a supplementary role in coding the information in the long-term mind in a more enriched and concrete manner thanks to Paivio's (1991) paired-coding method, which is one of the goals of Roundhouse Diagrams. Since computer support is believed to lead to important contributions to Roundhouse Diagrams with respect to developing students' creativity and relating their conceptual knowledge with more visuals, the present study is supported with computer use.

Roundhouse Diagrams

Roundhouse diagrams are a visual instruction tool developed by Wandersee. When the students use the roundhouse diagrams; they can construct textual parts with their sentences by using main concepts or main ideas in their minds. Afterwards, they place their sentences and figures on roundhouse diagrams (Ward & Wandersee, 2002a). In the process of the constructing roundhouse diagrams, students use their creativity, organize the knowledge as significantly and remember the knowledge easily (Bora at al., 2006; Ward & Wandersee, 2002a). For that reason roundhouse diagrams have known as an effective way to use principles of constructivist learning in classroom. A Roundhouse diagram is also an important material for teachers with a clear understanding of students' knowledge generated during/after instruction and enables the teacher time to correct misconceptions before testing (Wandersee, 1994; Trowbridge & Wandersee,1998). It helps teacher to identify and correct the students' misunderstanding immediately. The roundhouse diagram allows teachers to work with 'products of student thinking' by analysing the relationship between the visual representations drawn by the student and the targeted concepts taught in class. It is a useful work sample for understanding the students' viewpoint [for detailed explanation about roundhouse diagrams please look at Kocakaya (2011)].

PURPOSE

The purpose of the present study was to investigate the influence of computer-assisted Roundhouse Diagrams on secondary school 9th grade students' achievements in the subjects of "Force and Motion" and to evaluate the students' views about these materials.

In this study; that the roundhouse diagrams has some qualifications which support both aims of context-based learning and physics curriculum activities, we tried to reveal the usability of roundhouse diagrams.

For this purpose in this study; it was sought the answer of following questions that how the computer assisted roundhouse diagrams affect the 9th grade students' achievement on "Force and motion"

1. Are computer-assisted roundhouse diagrams having any effect on students' physics achievements?
2. Is there any significant differences between computer-assisted roundhouse diagrams and Context-Based Learning Approach on 9th grade students' achievement on "force and motion" when they compared?
3. What is the opinion of students on using roundhouse diagrams at physics education?

Research hypothesis (**H_0** and **H_1**) of this study are constructed below.

H_0 : There are not any differences between used methods.

H_1 : Computer aided roundhouse diagrams have more significant effect on students' physics achievement than control group.

METHOD

Research Model

The study was designed with the quasi-experimental model. Quasi-experimental models are research models that allow producing the data to be observed under direct control of the researcher for the purpose of determining the reason-result relationships (Karasar, 2005). In the study, the "pretest-posttest control-group model", which is among experimental models, was applied. In addition, in the study, the experimental group included the students from the class where computer-assisted Roundhouse Diagrams were used in other respects the Context-Based Learning Approach, while in the control group were students from the class where the Context-Based Learning Approach was used.

Participants

The present study was conducted with two groups which selected randomly 9th-grade students attending a high school in the province of Diyarbakır in Turkey in the Spring Term of the academic year of 2010-2011. One of the groups was determined as the control group and the other as the experimental group randomly. The students who did not participate in the whole data-collection process were not included in the data analysis process. As a result, the experimental group was included 30, and the control group was 17 students. As a result of pretest; it was observed these two groups were similar.

MATERIAL

In order to students' use during the lessons or out of the class environment, they were provided with an empty sheet of Roundhouse Diagram, the Roundhouse Diagram Worksheet and the Roundhouse Diagram Checklist.

1. Empty Sheet of Roundhouse Diagram

There was "My Roundhouse Diagram" on the top-left of the Roundhouse Diagram; "Student's Name-Surname" on the top-right; and "Purpose" at the bottom for the students to state the purpose of forming the Roundhouse Diagrams. The Roundhouse Diagram was made up of 7 sections. When necessary, it was possible to increase or decrease the number of the sections (with 2) that constituted the Roundhouse Diagram. Thus, in line with the demands of the students, empty sheets of Roundhouse Diagrams with at most 9 and at least 5 sections were formed.

2. Roundhouse Diagram Worksheet (Preliminary Preparation)

The "Roundhouse Diagram Worksheet" (it could be provided on demand) helped the teacher/student plan the things to do before forming the diagram. The worksheet included 6 items, and each item was related to the steps of forming the Roundhouse Diagram. These items were as follows;

1. "What is the main idea of the subject you examined? Write down your purposes of and reasons for forming the diagram." The teacher/student responding to this item determined the main subject or the concept as well as his or her purposes regarding the diagram. Setting the purpose allowed students to focus on the subject and to determine the procedure to follow.
2. "Write down your title in different ways using different prepositional phrases such as *of* or *for*." With this item, the teacher/student wrote

down the main titles in different ways using different structures such as prepositional phrases like *of* or *for* in a way to cover the overall subject or concept that he or she had determined in the first item.

3. "Write down your title meaningfully in two phrases using the conjunction of "*and*." In this item, the teacher/student divided his or her main title into sub-titles using the conjunction of "*and*". Determining the main title and the sub-titles gave the student an idea about the pieces of texts that he or she would place in the sections. The students responding to the 2nd and 3rd items wrote down the titles in their own words that they were supposed to organize in the curve of S within the central circle.
4. "Write down the main concept and later divide this main concept into seven pieces of texts (if necessary, it could be more or fewer)." In this item, the teacher/student determined the pieces of texts that he or she would place in the seven sections around the central circle to explain the main subject or concept and wrote them in his or her own words. These pieces of texts were expected to explain the main subject or concept and be related both with the main concept and with each other.
5. "Write down the number of each piece of text that you will write into the sections. In this way, when you write the numbers, you organize the information that you write for each section." In this item, the texts which are written by teacher/students' own words according to 4th item is numbered in a hierarchical for relation and statement order. In this way, the teacher/student determined which section to use for a piece of text.
6. "Draw a simple related object or a symbolic figure in the sections of the diagram. Use your imagination and be creative." In this item, for each piece of text, the teacher/students draw figures to explain or support that piece of text. These figures are formed in mind by stimulating texts that teacher/students written with their own words.

As a result, the teacher/students who responded to the 6 items in the Roundhouse Diagram Worksheet complete the steps of forming the roundhouse diagram. In this way, they complete the Roundhouse Diagram by setting their responses to the items in the empty sheet of Roundhouse Diagram. Thus, the teacher/students achieve the planning step which is one of the requirements of metacognitive learning by completing the Roundhouse Diagram Worksheet.

3. Roundhouse Diagram Checklist

In order to determine the procedure that the teacher/student would follow while forming the Roundhouse Diagram, they filled in the Roundhouse Diagram Checklist (it could be provided on demand). The Roundhouse

Diagram Checklist was a Likert-type scale including 10 items. These items help evaluate the quality of each step in the process of forming the diagram. The students responded to these items as 'Yes', 'Almost Complete', 'Incomplete' and 'No'. In this way, the students evaluate the quality of the followed procedure in the diagram by themselves. The teacher and students who finalize the roundhouse diagram checklist are also complete the necessary step of self-evaluation which is another necessity of metacognitive learning.

4. Software Support

An animation that could be played via the computer prepared by the researchers was used in the application. Each step of the animation was described and presented in Appendices 2a [for detailed explanation about animation of roundhouse diagrams please look at Kocakaya (2011)].

DATA COLLECTION TOOLS

1. Force and Motion Subject Achievement Test

In the study, the students' acquisitions and knowledge about the subject were measured with the "Force and Motion Subject Achievement Test" including 20 multiple-choice items developed by the researchers (*it could be provided on demand*). This achievement test was developed within the scope of the 9^{th} grade course of physics. By examining the indicator table prepared regarding the subject of Force and Motion within the curriculum of the course of physics, a pool of 70 questions was formed. The formed question pool was analysed by the views of three physics education experts, and the numbers of the questions in the pool were decreased to 33 with their views. Following this, the validity and reliability studies were conducted. The prepared 33-item test was piloted with 92 10^{th} grade students who were taught the subject of "Force and Motion" in the previous academic terms. While conducting the validity studies of the achievement test, the discrimination indices (D) and degrees of difficulty (P) for each item were calculated. By examining the values of P and D, a total of 13 questions were excluded. Thus, discrimination indices and degrees of difficulty of 20 questions appropriated to the purpose were numbered from 1 to 20 and were put into a multiple-choice test format. As a result, the achievement test was finalized. The average item difficulty index of the finalized achievement test was found as 0.542, and its average discrimination index was calculated as 0.49. As a result of the experts' views and item analysis, the content validity of the achievement test with 20 items was examined via the table of goals and acquisitions. In addition, in order to examine the reliability of the test, the responses of 92 students to the 20 items found in the achievement test were analyzed. As a result of the reliability analysis, the reliability coefficient of the achievement test was calculated with Spearman-Brown's split-half method. As a result of this calculation, the reliability coefficient of the whole test was found as 0.93.

2. Force and Motion Subject Short-Answer Questions Test:

In the study, the "Force and Motion subject Short-Answer Questions Test" made up of 20 questions examining the students' knowledge of concepts found in the subject as envisaged in the curriculum was used (*the test could be provided on demand*). The first 15 questions of this test were fill-in-the-blanks type of questions interrogating the concepts of the subject, and the other five questions were true-false questions regarding the propositions. In addition, in order to understand why the students marked the true or false option for the last five questions and to determine their possible misconceptions - if any -, the word of 'because' was added to these five questions. With this word of 'because', the students were asked to shortly explain why they chose *true* or *false*. The researchers benefitted from 9^{th} grade physics textbooks, workbooks and related scientific articles related. Regarding the content validity, both experts and the experienced physics teacher were asked for their views. In addition, this test was applied to a group of upper-grade students to test its understandability. As two of the 15 fill-in-the-blank questions found in the short-answer questions test included more than one blank (14^{th} and 15^{th} questions), only the clarity for understanding of these two questions was examined. In other respects, for the remaining 13 questions, reliability analysis was conducted. In order to calculate the reliability coefficient for these 13 short-answer questions, Spearman-Brown's split-half method was used. As a result of this calculation, the reliability coefficient of the test was found as 0.82.

3. Questionnaire for Roundhouse Diagram Student Views:

In the study, the "Student Evaluation Checklist" developed by Ward and Wandersee (2002a) was used to determine the students' views about the "Roundhouse Diagram". This questionnaire was translated into Turkish by Bora et. al. (2006) and modified by Ermiş (2008) by adding 3 open-ended questions into the questionnaire to investigate the students' positive and negative views about the Roundhouse Diagram. 16 Likert-type propositions found in the questionnaire regarding the Roundhouse Diagram included such options as "Always", "Usually", "Sometimes" and "Never". The Cronbach-alpha value calculated for this scale was found as 0.75. The purpose of the questionnaire was to determine the students' views about whether the Roundhouse Diagrams had influence on their learning and understanding the physics concepts. In addition, the students' negative/positive views about the Roundhouse Diagrams were revealed with 3 open-ended questions.

THE EXECUTION PROCESS OF THE APPLICATIONS

The application was carried out with 9th grade students attending a high school in Diyarbakır province. All the phases of the application were conducted by the physics teacher in that school under the supervision of the researchers. The application part of the study lasted 6 weeks (12 course hours). During this period of time, the subjects envisaged by the Ministry of National Education in the subject of “Force and Motion” were taught, and no other subjects related to other subjects were taken into consideration. Before the application, the experimental group students were informed with the help of an animation about how to form Roundhouse Diagrams. Following this, the students were asked to form Roundhouse Diagrams regarding any of the sub-subjects of the previous subject, and the deficiencies found in the Roundhouse Diagrams that the students formed were determined and removed. After the application started, subject-related Roundhouse Diagrams were individually formed by each student at the end of each sub-subject of the subject. During the preparation of the Roundhouse Diagrams, the Roundhouse Diagram Worksheet and the Roundhouse Diagram Checklist were given to the students. First, the students were asked to fill in the Roundhouse Diagram Worksheets and then to form the Roundhouse Diagram related to the subject. In addition, common Roundhouse Diagrams were formed together with the students via computer support in class.

In the process of forming the Roundhouse Diagram, the students who is forming the diagram were asked to write down the subject-related key concepts in their own words by using such prepositional phrases as “of” and “for” and to write the sub-concepts related to the key concepts into the appropriate places in the middle circle using the conjunction of “and”. Following this, they were asked to write down the seven pieces of texts - which were related to the concept in the center and which they restated in their own words - in order in the sections around the circle. In the last phase, the students were asked to draw simple images and figures representing the pieces of texts in the sections. In the process, the teacher encouraged the students to become creative. At the end of each subject lesson, the students formed the Roundhouse Diagrams. Afterwards, these Roundhouse Diagrams were taken back from the students for evaluation. In addition, the students formed Roundhouse Diagrams with the help of the teacher via computer in class. Two samples of the Roundhouse Diagrams formed individually by the students are presented in Appendix 1. The students were asked to examine themselves the Roundhouse Diagrams they formed and to fill in the Roundhouse Checklist so that they could see and evaluate how good the method they applied was. In this way, the students formed Roundhouse Diagrams regarding all the subjects and sub-subjects to be taught throughout the subject of "Force and Motion".

DATA ANALYSIS

Answer keys were prepared for the achievement test and for the test of short-answer questions. As '1' point was given to each correct answer in the Force and Motion Subject Achievement Test, the highest score that could be taken from this test by the students was equal to the total number of the questions found in the test. As for the test of short-answer questions, the highest score that could be taken by the students if they answered all the questions correctly was determined as 100 (due to the structure of the questions found in this test). Regarding the first 14 fill-in-the-blank questions, '3' points was assigned for each blank; '8' points to the 15th question; and '7' points was assigned to the 16th, 17th, 18th, 19th and 20th questions. The students were asked to avoid responding to any question or proposition that they did not have any opinion about its answer. The students' scores were calculated considering their responses to the questions and propositions both in the Force and Motion Subject Achievement Test and in the Force and Motion Subject Short-Answer Questions Test. As for the Questionnaire for Roundhouse Diagram Student Views applied to the experimental group students, the percentages of their responses to the questionnaire were calculated; in addition, their responses to each proposition found in the Questionnaire for Roundhouse Diagram Student Views were scored as 4 for 'Always'; 3 for 'Usually'; 2 for 'Sometimes'; and as 1 for 'Never'. Depending on the students' responses to the propositions in the questionnaire, the mean scores regarding each proposition were calculated. For the analysis of the data obtained via the questionnaire, the following scale was taken into consideration regarding the calculation of the mean scores:

If the scores were in the range of
1.00-1.74, then they were considered as Never (1),
1.75-2.50, then they were considered as Sometimes (2),
2.51-3.25, then they were considered as Usually (3), and
3.26-4.00, then they were considered as Always (4).

The students' responses to the open-ended questions were examined and gathered under certain themes. For first-hand evaluation by the readers, the students' responses were transferred as they were.

The quantitative data obtained in the present study were analysed with the package software of SPSS 15.0.

FINDINGS

In this part, the findings obtained as a result of the analysis of the data collected via the data collection tools within the scope of the study are presented in Tables. While examining the data obtained via the “Force and Motion Subject Short-Answer Questions Test” and the “Force and Motion Subject Achievement Test” used to determine the students’ achievement, paired and independent sample t-tests and the means and percentages in the Questionnaire for Roundhouse Diagram Student Views were used. As no significant difference was found between the experimental and control groups as a result of the pretests conducted, only the differences between the posttests were compared.

Table 1 presents the independent sample t-test comparisons of the posttest results of the Force and Motion Subject Achievement Test for the experimental and control groups.

Table 1. Independent Sample t-test Results of the Posttest of the Force and Motion Subject Achievement Test for the Experimental and Control Groups

	(N)	Mean ($\overline{X}$)	Standard Deviation (SD)	df	t	P
Experimental Group	30	6.4	2.990	45	2.531	0.015*
Control Group	17	4.41	1.662			

*P<0.05

At the end of the study, the results of the Force and Motion Subject Achievement Test applied to the experimental and control groups revealed that the experimental group was more successful than the control group.

Table 2. Independent Sample t-test Results of the Posttest of the Force and Motion Subject Short-Answer Questions Test for the Experimental and Control Groups

	(N)	Mean ($\overline{X}$)	Standard Deviation (SD)	df	t	P
Experimental Group	30	30.65	16.980	45	4.264	0.001
Control Group	17	12.18	7.064			

P<0.05

Table 2 presents the independent sample t-test comparisons of the post-test results of the Force and Motion Subject Short-Answer Questions Test for the experimental and control groups.

At the end of the study, when the scores of the Force and Motion Short-Answer Questions Test applied to the experimental and control groups were compared, it was seen that the experimental group had a higher level of conceptual achievement.

Table 3 presents the paired sample t-test comparisons of the pretest-posttest results of the Force and Motion Subject Achievement Test for the experimental and control groups.

Table 3. Paired Sample t-test Results of the Pretest-Posttest of the Force and Motion Subject Achievement Test for the Experimental and Control Groups

Group	Test	(N)	Mean ($\overline{X}$)	Standard Deviation (SD)	df	t	P
Experimental	Pretest Posttest	30	4.77 6.40	2.930	29	3.053	0.005
Control	Pretest Posttest	17	4.29 4.41	1.900	16	0.255	0.802

According to the results of the paired sample t-test of the data obtained via the Force and Motion Subject Achievement Test applied to the experimental group students before and after the study, the experimental group students' levels of achievement increased significantly ($P<0.05$). In addition, the results of the paired sample t-test analysis conducted revealed an increase in the control group students' achievement, yet it was not statistically significant ($P>0.05$).

Table 4 presents the paired sample t-test comparisons of the pretest-posttest results according to the experimental and control groups' responses to the Force and Motion Subject Short-Answer Questions Test.

Table 4. Paired Sample t-test Results of the Pretest-Posttest of the Force and Motion Subject Short-Answer Questions Test for the Experimental and Control Groups

Group	Test	(N)	Mean ($\overline{X}$)	Standard Deviation (SD)	df	t	P
Experimental	Pretest Posttest	30	5.83 30.63	14.116	29	9.623	0.001
Control	Pretest Posttest	17	7.35 12.18	5.992	16	3.319	0.004

Before and after the study, paired sample t-test was applied to the data obtained via the Force and Motion Short-Answer Questions Test conducted with the experimental and control group students. The results revealed a statistically significant increase in both experimental and control group students' achievements ($P<0.05$).

It was seen that experimental group which thought with computer aided roundhouse diagrams has statistically more efficient than control group. Sometimes those differences may reveal from the sample size. For that reason effect size of the data calculated and it was seen that there is a medium effect size ($\eta^2=0.12$ d=0,38) of the roundhouse diagrams on students' physics achievement. Furthermore; Null hypothesis of this study was rejected and main hypothesis was accepted **($H_1>H_0$)**.

In addition, in order to determine the students' views about the Roundhouse Diagram in the study, the "Questionnaire for Roundhouse Diagram Student Views" was applied. Table 5 presents the distributions of the responses to this questionnaire in percentages.

Table 5. Percentages of the Responses to the Questionnaire for Roundhouse Diagram Student Views

Statements	Always %	Usually %	Sometimes %	Never %	Empty %
1. I enjoyed studying with the Roundhouse Diagram (RD).	69.6	4.3	13.0	13.0	-
2. I answered the questions related to the subject in the RD Worksheet.	30.4	17.4	43.5	8.7	-
3. I looked for and found beneficial sources such as course books and drawing books and made good use of these sources.	56.5	13.0	21.7	8.7	-
4. I collected all the necessary information about the subject.	69.6	13.0	17.4	-	-
5. I planned and organized RD well.	60.9	17.4	17.4	4.3	-
6. I can effectively restate summarized information in other words.	30.4	13.0	39.1	13.0	4.3
7. I prepared and presented the information effectively and interestingly.	43.5	17.4	21.7	17.4	-
8. I used the time well while studying with RD.	69.6	8.7	13.0	8.7	-

Table 5. Percentages of the Responses to the Questionnaire for Roundhouse Diagram Student Views (cont.)

Statements	Always %	Usually %	Sometimes %	Never %	Empty %
9. I could form RD on my own.	73.9	4.3	21.7	-	-
10. I can form RD well together with my friends.	65.2	8.7	13.0	13.0	-
11. I wrote down the information in my own words.	30.4	13.0	30.4	26.1	-
12. I associated the images appropriate to the concepts well with each other.	60.9	-	17.4	17.4	4.3
13. I was creative while forming RD.	47.8	13.0	13.0	26.1	-
14. I realized that RD was a tool that contributed to learning.	60.9	4.3	21.7	13.0	-
15. I prefer using RD to taking notes in the lesson.	47.8	13.0	13.0	17.4	8.7
16. I believe RD will help me understand and develop science-related concepts.	60.9	4.3	13.0	17.4	4.3

Following the applications, in line with the experimental group students' responses to the Questionnaire for Roundhouse Diagram Student Views, it was seen that among the students, 69,6% of them enjoyed studying with the Roundhouse Diagram (proposition 1); that 69,6% of them gathered all the necessary information about the subjects (proposition 4); that 60,9% of them planned and organized the Roundhouse Diagram well (proposition 5); that 73% of them were able to form the Roundhouse Diagram on their own; and that 65,2% of them were able to form the Roundhouse Diagram with the help of their friends (propositions 9 and 10). In addition, 60,9% of the students realized that the Roundhouse Diagram was a tool beneficial for learning and believed that it would help them understand and develop science-related concepts (proposition 14). It was also seen that most of the students responded as "Always" and "usually" to the propositions regarding their own views about the Roundhouse Diagram. Moreover, for the propositions investigating the formation of the Roundhouse Diagram, 26,1% of the students reported that they had difficulty writing down the information in their own words and using their creativity (propositions 11 and 13).

The students' responses to the propositions in the Questionnaire for Roundhouse Diagram Student Views were scored, and for each proposition, the mean scores were calculated. The mean scores found for each proposition are presented in Table 6.

Table 6. Mean Scores Regarding the Students' Views Determined via the Questionnaire for Roundhouse Diagram Student Views

Propositions	Students' Scores Mean	Mean Scores Regarding the Students' Responses
1. I enjoyed studying with the Roundhouse Diagram (RD).	3.20	Usually
2. I answered the questions related to the subject in the RD Worksheet.	2.63	Usually
3. I looked for and found beneficial sources such as course books and drawing books and made good use of these sources.	3.06	Usually
4. I collected all the necessary information about the subject.	3.33	Always
5. I planned and organized RD well.	3.06	Usually
6. I can effectively restate summarized information in other words.	2.50	Sometimes
7. I prepared and presented the information effectively and interestingly.	2.73	Usually
8. I used the time well while studying with RD.	3.13	Usually
9. I could form RD on my own.	3.36	Always
10. I can form RD well together with my friends.	3.33	Always
11. I wrote down the information in my own words.	2.30	Sometimes
12. I associated the images appropriate to the concepts well with each other.	2.96	Usually
13. I was creative while forming RD.	2.80	Usually
14. I realized that RD was a tool that contributed to learning.	3.13	Usually
15. I prefer using RD to taking notes in the lesson.	2.83	Usually
16. I believe RD will help me understand and develop science-related concepts.	2.96	Usually

The results of the analysis of the data obtained via the Questionnaire for Roundhouse Diagram Student Views revealed that a majority of the mean scores regarding the propositions (93.75%) belonged to such responses as "Always" and "Usually". This result demonstrated that the students had positive views about the Roundhouse Diagram.

The students' responses to the open-ended questions in the Questionnaire for Roundhouse Diagram Student Views are presented below to help readers gain insights.

Some of the students' responses to the question of "Write down the most important things that you have learnt while forming the Roundhouse Diagram" are as follows:

- *"I recalled all the concepts with the help of the related images and I participated in the lessons almost all the time."*
- *"I learnt by heart the concepts of the Force and Motion subject without having any difficulty."*
- *"I have got used to doing my homework."*
- *"I learnt the definitions without any difficulty by writing down short sentences."*
- *"I can both understand well and remember easily via the Roundhouse Diagram."*
- *"One can remember much more easily by writing and via images."*
- *"I learnt that knowledge becomes permanent thanks to images."*
- *"I don't need to take notes any longer during the lesson, and I learnt how to use the time."*
- *"I learnt the force and motion subject better thanks to the roundhouse diagram."*
- *"I learnt to associate images with definitions."*
- *"I realized that while preparing the roundhouse diagram, I better understood some subjects which I didn't know, or those which I couldn't understand."*
- *"I realized that I understood everything better while filling in the roundhouse diagram. I prefer to use the roundhouse diagram more to taking notes during the lesson."*
- *"I memorized the definitions of the concepts well and understood the relationships between the concepts."*

Some of the students' responses to the question of "Write down the problems if you say Yes to the question of 'Have you ever experienced any problem while forming the Roundhouse Diagram?'" are as follows:

- *"I had difficulty finding the images."*
- *"I had difficulty forming it."*

- *"Yes, I sometimes had difficulty. I experienced problems with planning."*
- *"It was difficult at the beginning while preparing the roundhouse diagram. But later, as I did it, I understood it was easy"*
- *"It was very entertaining. I didn't have any difficulty."*
- *"I mostly abstained from comparing and defining."*
- *"I couldn't associate the images well with the definitions."*
- *"I have difficulty setting out, but once I start, I can easily complete it."*
- *"Yes, I didn't know how to do it at the beginning."*
- *"Thanks to my teacher, I didn't experience any problem. I believe I did it well."*

Some of the students' responses to the question of "Write down your positive or negative views about the Roundhouse Diagram" are as follows:

- *"I entertained a lot while forming the roundhouse diagram."*
- *"The roundhouse diagram is quite good because I can understand the lesson better with the help of those images."*
- *"It was interesting and nice."*
- *"It helped with my lessons. Instead of taking notes, the information in the roundhouse diagram was sufficient for me."*
- *"The roundhouse diagram helps understand the physics lessons better."*
- *"It was entertaining."*
- *"The roundhouse diagram is both very entertaining and beneficial for the lessons."*
- *"I believe the roundhouse diagram is a useful study-method for better education. When you forget things, you can recall the related images. In this way, you can remember the definitions."*
- *"It helps make your knowledge permanent. Drawing the images of concepts helps you remember the related information more easily."*
- *"I think it is quite good because, in this way, you can understand better via visuals."*
- *"I benefitted from the roundhouse diagram, and I wish it were used in other courses as well."*
- *"It helps learn physics lessons and enjoy the course."*
- *"It is very nice and creative."*
- *"At times when I didn't understand how to fill in the roundhouse diagram, I couldn't learn anything, but later, I learnt it, and it was beneficial."*

When the students' responses to the open-ended questions in the Questionnaire for Roundhouse Diagram Student Views were examined, it was seen that they enjoyed forming these diagrams and that they believed it was beneficial for learning the subject. Some of the students pointed out that they experienced problems at most both in finding images appropriate to the pieces of texts and in associating the images with the pieces of texts.

Considering the statements above as a whole, the students' views about Roundhouse Diagrams could be gathered under the following themes:

- Appreciating the materials
- Enjoying studying with the materials
- Willingness to use materials during the lesson
- Participation in the lesson
- Difficulty in becoming creative

DISCUSSION

When the findings obtained in the present study are examined, it was seen that the Computer-assisted Roundhouse Diagrams contributed both to the students' understanding of the subject of `Force and Motion` and to their conceptual achievements (Table 1 and Table 2). It is also reported by other researchers using the Roundhouse Diagrams in their experimental studies that lessons supported with Roundhouse Diagrams contribute to students` achievements in science (Bora et. al., 2006; Ermiş, 2008).

In addition, there was an increase in the achievements of the students found in the group in which Roundhouse Diagrams were not used, yet it was seen that the increase was not statistically significant (Table 3). Although the lessons were taught by the same teacher in both groups, no statistically significant difference was found between the pretest and posttest scores of the control group students. Depending on this result, it could be stated that use of Roundhouse Diagrams is important in increasing students` achievements in courses. In secondary schools of the Ministry of National Education, a new education program has been in use since the academic year of 2008-2009. Application of this new education program in which activity-based education system is used causes both teachers and students to feel restless regarding preparation for placement exams for Higher Education. Such restlessness occurs mostly due to whether the curriculum applied fits the contents of these placement exams for Higher Education (Uğurel et. al., 2010). In addition, the high level of achievement in the group in which Computer-Supported Roundhouse Diagrams were used demonstrates that this technique could help overcome such restlessness. The reason is that according to the results of the same test, there was no significant increase in the achievements of the students in the control group in which Computer-Assisted Roundhouse Diagrams were not used. The physics textbooks were prepared in line with the Context-Based Learning Approach supplemented with daily-life activities. Because the students did not carry out the activities in class environment or because the teachers' explanations regarding the activities were inefficient and limited, the students had difficulty understanding the subjects of the subjects. In the present study, based on the fact that there was no significant increase in the control group students' achievements, it could be stated that the context-based learning approach may not be effective alone. Therefore, it is necessary to support this approach with techniques that allow using different materials. Moreover, it was also seen that although no significant difference was found in the control group students' achievements in the multiple-choice Force and Motion Subject Achievement Test, the Force and Motion Subject Short-Answer Questions Test significantly increased the students' achievements. This result could be said to be due to the high number of memorization-based questions in the Force and Motion Subject Short-Answer Questions Test.

There were True-False questions in the Force and Motion Subject Short-Answer Questions Test. Each of these two-option questions was followed by a part that the students were asked to complete to explain the reason for their choice by starting with the word of "because". The purpose was to reveal not only the reasons for their choices but also their misconceptions regarding the subject. When the Roundhouse Diagrams formed by the experimental group students who had misconceptions were examined, it was seen that they generally reflected their misconceptions into the visuals they drew. It was also seen that some of the students who were warned by the teacher due to their misconceptions in their Roundhouse Diagrams did not repeat some of these misconceptions in the posttest. Based on these results, Roundhouse Diagrams could be said to be an effective material in determining and overcoming misconceptions.

The Roundhouse Diagrams formed by the students and the Roundhouse Diagram Checklists filled in by them were gathered and examined. The results of the examination of the checklists revealed that the students were generally able to evaluate their Roundhouse Diagrams and that most of the students were aware of their own deficiencies. It was also seen that the students recognizing their own deficiencies overcame these deficiencies in the Roundhouse Diagrams they formed.

Lastly, when Table 5 and Table 6 are examined together, it was seen that in line with the students' responses to the propositions in the Questionnaire for Roundhouse Diagram Student Views applied to the experimental group, the students enjoyed studying with the Roundhouse Diagram technique without having much difficulty and developed their creativity. Students can form Roundhouse Diagrams on their own or with their friends. It is believed that all such activities could make students more active both in in-class and out-of-class environments and could enrich exchange of ideas between students. In addition, it was seen that some of the students had difficulty rephrasing the statements in their own words and failed to associate them with the images while forming the Roundhouse Diagram. Therefore, Roundhouse Diagrams should be introduced to students well, and they should be encouraged to develop self-confidence. In general, it was seen that the Roundhouse Diagrams contributed to the students' learning processes and that they believed it was a beneficial tool as a technique for learning concepts.

The results of the present study are limited to the students in the group as well as to the subject of "Force and Motion" found in the high school 9th grade curriculum. The Roundhouse Diagram used in the experimental group could be considered as a new material since it was introduced in 1994. Although this material was introduced in 1994, it was first tested in 2002 by its developers, Ward and Wandersee. Thus, there is limited research on the use of this material in educational environments with its short history of 10 years both in the country and abroad.

Due to all the reasons mentioned above, the generalizability of the results obtained in the present study is limited. Studies to be conducted by groups of a number of researchers could allow making clearer interpretations regarding the effectiveness of the use of Roundhouse Diagrams in educational environments.

CONCLUSIONS AND SUGGESTIONS

The following results were obtained in the present study; which aimed to determine the influence of "Computer-Assisted Roundhouse Diagrams" on high school 9th grade students' academic achievements and which aimed to reveal their views about these diagrams.

The results regarding the influence of the Roundhouse Diagram technique and the curriculum applied following the study on the students' achievements in the subject of "Force and Motion" are presented in Table 1, Table 2, Table 3 and Table 4. When these Tables are examined together, it could be stated that Roundhouse Diagrams increased the students' academic achievements in the subject of "Force and Motion". Other studies carried on Roundhouse Diagrams also support this result (Bora et. al., 2006; Ermiş, 2008; Kocakaya, 2011).

It was seen that the Roundhouse Diagrams formed by the students helped the course teacher to determine the students' misconceptions. Teachers can determine both students' knowledge about the subject and their misconceptions regarding the subject thanks to the Roundhouse Diagrams formed. The Roundhouse Diagram Checklists filled in by the students allowed developing their ability to evaluate the materials they formed. This not only raises students' awareness of their own creativity levels and their lack of knowledge about subjects but also raises their awareness of how information is processed in mind.

Students generally stated that they enjoyed studying with Roundhouse Diagrams and that Roundhouse Diagrams helped them to learn the subjects of "Force and Motion". While some of the students reported that they experienced difficulty both in planning and in associating the pieces of texts with the images in the process of forming the Roundhouse Diagrams, a majority students pointed out that they could form the Roundhouse Diagram alone (Table 5). It was seen that most of the students responded to the propositions in the questionnaire saying "Always" or "Usually" (Table 6). Based on this result, it could be stated that the students had positive views about Roundhouse Diagrams.

Taking the results of the present study as well as those of other studies into consideration, it is understood that Roundhouse Diagrams can be used both in elementary schools and in secondary schools. In addition, with respect to their constructs and goals, Roundhouse Diagrams apparently supplement the activities found in the physics curriculum.

Based on the findings obtained in the study as well as on the experiences in the application process, the following suggestions could be put forward for more effective use of Roundhouse Diagrams in educational environments:

- It is believed that Roundhouse Diagrams could help both developing creativity and facilitating learning since it is a visual material.
- Prior to the applications of Roundhouse Diagrams, with the help of preliminary work on simple and comprehensible subjects, students should be made to know the purpose of Roundhouse Diagrams and to learn how to form them. Otherwise, students who fail to form the Roundhouse Diagram are likely to, have negative attitudes towards the course.
- In student groups with a low level of cognition, they should be asked to complete the Roundhouse Diagram after forming the main-concept titles in the central circle as well as the purpose.
- The students who form the Roundhouse Diagram are likely to construct the concept wrongly, and this may cause students to have misconceptions. The Roundhouse Diagrams formed by the students should be checked by the course teachers to avoid any misconceptions.
- In case of time limitations, in order to develop students' creativity and save the time, it may be necessary to use appropriate visuals more. For this purpose, computers could be used.

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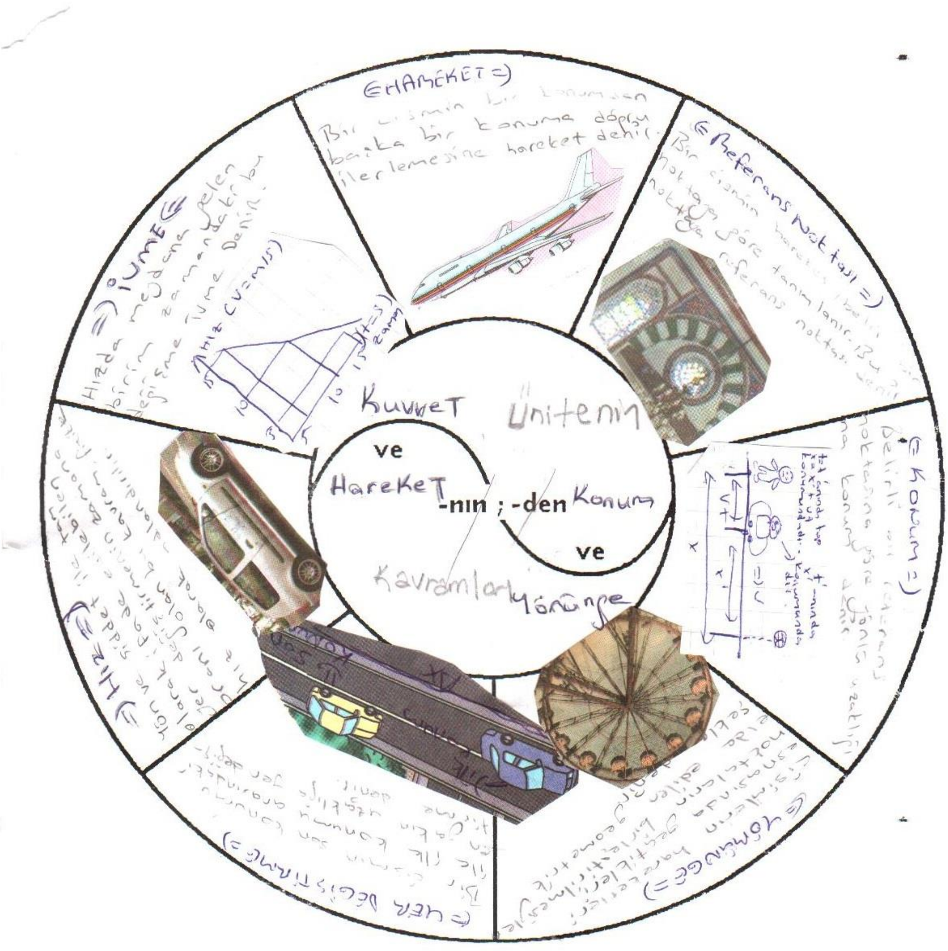
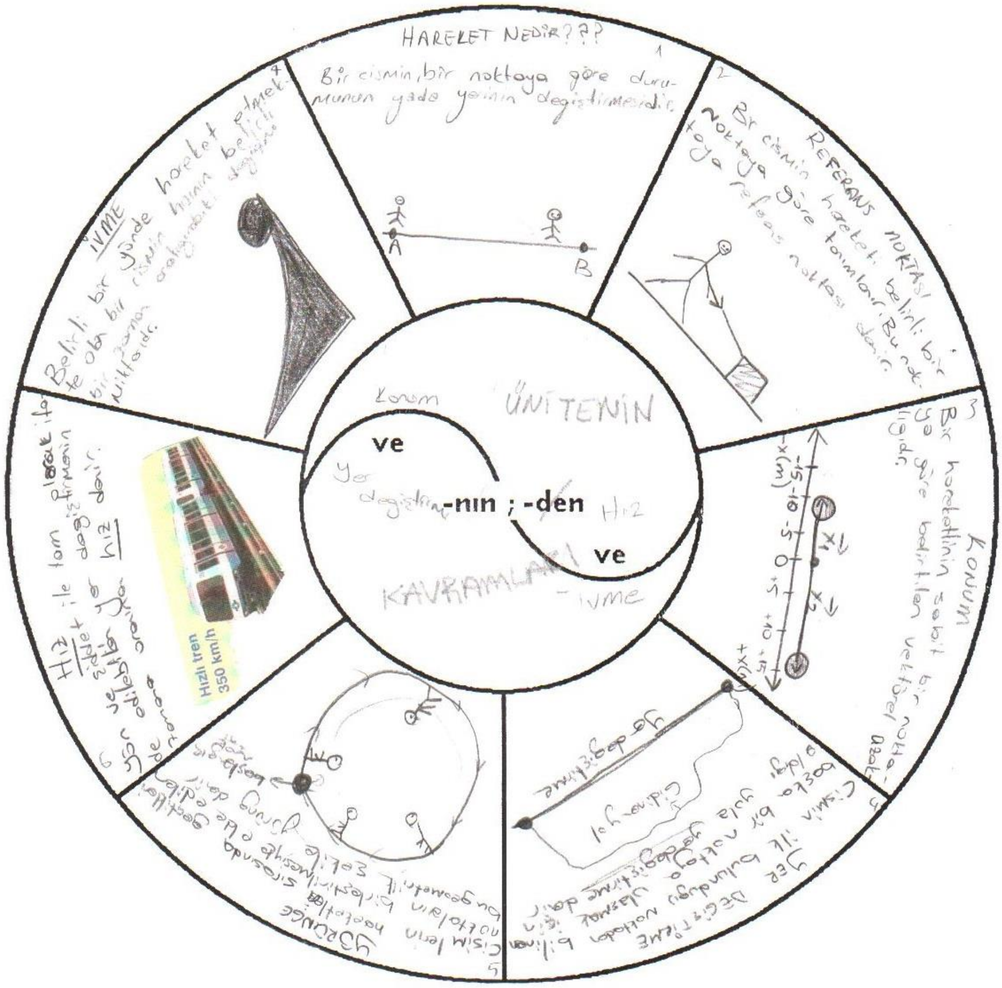
APPENDICES

Appendix 1 Samples Prepared by Students



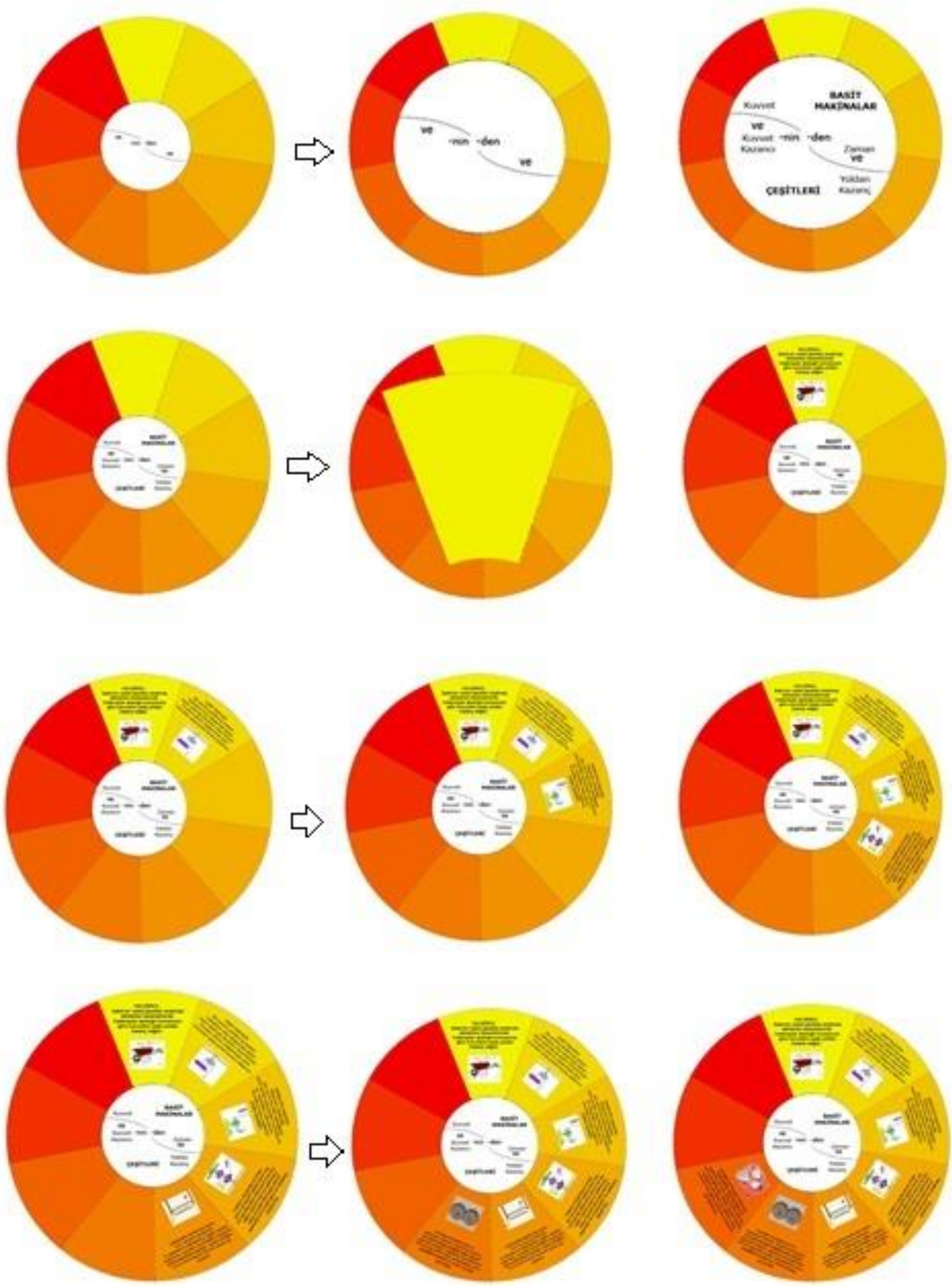
Amaç: Kuvvet ve Hareketin kavramlarının anlamını açıklamak.

Appendix 1 Samples Prepared by Students (cont.)

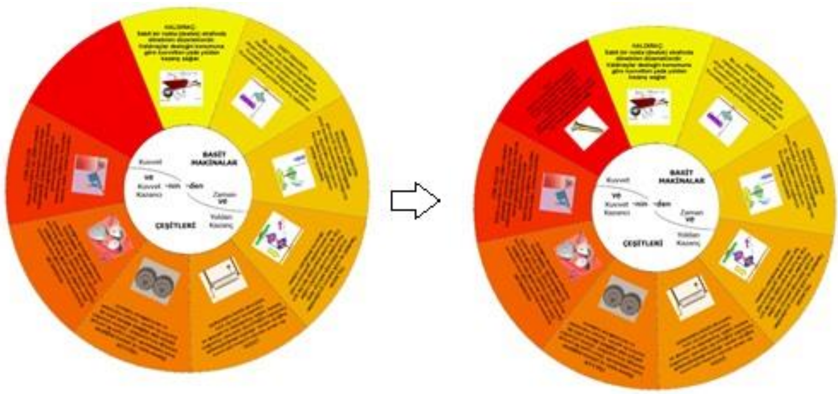


Amaç: Kuvvet ve Hareketin nasıl oluştuğu ve kuvvetin kavramlarını öğrenmek için bu kavram çarkını yapacam

Appendix 2 Steps of the Roundhouse Diagram Animation



Appendix 2 Steps of the Roundhouse Diagram Animation (cont.)



Appendix 3 Images in the Classroom