



MATHEMATICAL ACTIVITY DESIGNS CONDUCTED WITH E-PORTFOLIO BY SECONDARY SCHOOL STUDENTS WITHIN THE FRAMEWORK OF REALISTIC MATHEMATICS EDUCATION

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Abstract:

Design thinking skill is perhaps the most directly related thinking skill of mathematical thinking skill, because design thinking contains a strong problem-solving process in itself. In this study, it was aimed to provide students to avoid thinking about mathematics only procedurally or instrumentally and to introduce them to mathematical studying methods and mental habits. Therefore, tasks were chosen that would encourage students to think and design using real-life mathematical elements and thus encourage effective mathematical thinking. According to Freudenthal, the theorist of the Realistic Mathematics Education, mathematics should be related to the social life of students, close to their experiences, relevant to the society they live in, and compatible with human values. The research is designed as “action research” which is one of the qualitative research methods. Participants were selected using the convenience sampling method. Edmodo software was used as an electronic portfolio. Activities were prepared within the framework of RME approach. The responses are given by the students to those activities distributed when examined under 5 main headings: designing products, expressing the mathematical opinions clearly, using the mathematical knowledge, the research skills and the originality. These criteria generated after taking an expert opinion, subjected to qualitative analysis and interpreted. Consequently, it can be concluded that the educational process which is carried out with design-based activities provides learning, and is relevant to daily life, is interesting and is motivating. The integration of face-to-face teaching with technology and online approaches also help teachers manage design-based activities in a more effective way.

Keywords: design thinking, e-portfolio, mathematical thinking, realistic mathematics education, real life math questions

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1. Introduction

There are many different definitions and interpretations about the term of mathematical thinking. We all have an intuitive sense of what this term means, and it is almost impossible to formulate a clear definition of it. However, we know that mathematical thinking skill has a structure affecting and enhancing many thinking skills in individuals. For this purpose, we aim to encourage our students to think mathematically in mathematics education. Design thinking skill is perhaps the most directly related thinking skill to mathematical thinking skill, because design thinking is a powerful problem-solving process and the relationship between problem solving and mathematics is known. In fact, we can say that design thinking, which is an innovation process that includes concept development, applied creativity, prototyping and experimentation, is a reflection of mathematical thinking skills. The problem-solving habits of students in school mathematics are problem-solving habits that mostly involve applying some memorized rules that require arithmetical operation skills. However, when considering that mathematical tasks are the tools used to initiate mathematical activity, research has indicated that the task types assigned to students widely affect the types and processes of thinking they engage in, their level of participation and thus the learning outcomes obtained. In fact, Stein et al. (1996) argue that the tasks students engage in go beyond directing students the content they learn and can determine *“how they will think, develop, use, and interpret mathematics.”* Being exposed to familiar or routine tasks alone affects the student's ability to reason, to answer unknown questions, and to transfer knowledge (Mac an et al., 2010). In a study conducted about effective mathematics programs in the USA, Ellis et al. (2015) found that homework which includes new and cognitively challenging tasks is important for the development of comprehension and confidence of the student. However, studies conducted internationally [e.g., in the United Kingdom (Sangwin, 2003) and Ireland (Stein et al. 1996)] suggest that in the introduction to mathematics course, undergraduate students mostly need to perform procedural calculations and rarely need to use high level thinking skills.

In this study, we aimed to conduct a study that aims to keep students away from thinking about mathematics only procedurally or instrumentally and to introduce them to mathematical study methods and mental habits.

For this purpose, after referring to the literature, we chose the types of tasks that direct students to think and to design with real-life mathematical elements and thus encourage effective mathematical thinking. While selecting these tasks, we aimed to evaluate and present students' designs according to the mathematization steps of RME (Realistic Mathematics Education). According to Freudenthal, the theorist of RME, mathematics should be related to the social life of students, close to their experiences, relevant to the society they live in, and compatible with human values. In reference to this approach, mathematics should be presented to students as a branch of science that they can reshape by practicing it themselves with the guidance of their teachers. The essential point here is that mathematics is not seen as a closed system, but the principle

of showing that mathematics education is a structure that is evolving all the time (Freudenthal, 1968). Later, another mathematics educator Treffers (1993) who contributed to the RME approach in 1978-1987 divided mathematization into two separate types, horizontal and vertical. In horizontal mathematization, students can develop a mathematical tool and solve the problematical situations they encounter in their real life. In vertical mathematization, students can make new connections between mathematical concepts, create shortcuts, or organize a mathematical system again. Also, it should not be forgotten that mathematization is a phenomenon that students can create different thresholds of understanding. Additionally, it should not be forgotten that mathematization is a phenomenon that students can create different thresholds of understanding. In horizontal mathematization, students move from the world they live into the world of symbols, but they move within the world of symbols in vertical mathematization (Freudenthal, 1991). However, according to Freudenthal, the distinction between these two types does not have sharp boundaries and both mathematization methods are recognized as equivalent.

Horizontal and vertical mathematization exist in other mathematics education approaches at a certain level, but the RME approach includes both methods of mathematization by differing from other approaches. In this study, we will consider the mathematization skills as a whole mathematization skills rather than separating them as horizontal and vertical in the direction of Freudenthal's approach.

Our study includes a task design and students are asked to make designs with certain qualities. Many studies have been conducted about ideal task designs in mathematics and the characteristics requested in the sequence of tasks. The studies of Swan (2008), Sangwin (2003) and Stein (1996) can be given as an example. Swan (2008) focused on encouraging conceptual understanding in middle school students and identified five types of tasks he deemed appropriate for this purpose: classifying mathematical objects, interpreting multiple representations, evaluating mathematical statements, creating problems, and analysing reasoning and solutions. Sangwin (2003) presented a different viewpoint and classified the types of mathematical tasks actually used in university modules. Stein et al. (1996) discussed the importance of involving students in thinking, reasoning, and meaning-making processes. They identified the characteristics of a mathematical task as the multiple representation potential, the existence of multiple solution strategies, and the degree to which the task demands explanation and/or justification from students. In our research, we found it appropriate to focus on these elements while evaluating student tasks. In particular, we focused on seeing the potential of multiple representation, explanation and justification, and the ability of mathematization, and to see the contribution of the student designs to the meaning-making process.

Design activities are an interdisciplinary approach that combine science, mathematics and technology knowledge (Brophy et al., 2008), and they contribute to the development of creative thinking, problem solving and communication skills of students. In addition, some studies have stated that integrating design activities into mathematics

courses facilitates the learning of mathematics (Cantrell et al., 2006). As it is known, everybody encounters problem solving situations in the course of their lives, similar situations are also valid for design activities (Fortus et al., 2005). We use the appropriate tools and materials to change our environment in the direction of our needs, we actually design it, and designing is actually a basic human ability (Roberts, 1995). Therefore, design-based activities also have the potential to address the basic capacity of all students (Fortus et al., 2005).

In the design activities explained by Kolodner (2002), students participate in design problems. They comprehend the content of the related course while solving design problems. In this process, students have the opportunity to improve their conceptual comprehension by reinforcing previous ideas or confronting misunderstandings and retesting and changing. In fact, many educators organize learning around a design model consisting of stages such as experimenting, researching, testing, improving and evaluating (Dillon & Howe, 2007). From another perspective, design-based learning is a special form of project-based learning (Barron et al., 1998).

In this study, it was aimed to evaluate the activities prepared within the scope of realistic mathematics education, which was selected as the theoretical framework, and student designs based on the criteria formed by taking expert opinion.

2. Research Question

How are the responses given by the students to the activities prepared within the framework of the RME approach distributed when examined under 5 main headings (designing products, expressing the mathematical opinions clearly, using the mathematical knowledge, the research skills and the originality)?

3. Literature Review

Gravemeijer and Doorman conducted a study in 1999 titled "Context Problems in Realistic Mathematics Education: A Calculus Course as an Example." In this study, they aimed to examine the context problems in the Dutch education system where the realistic mathematics education approach is used. They planned their research as an instructional design and focused on how traditional mathematics can be reinvented. Context problems are composed of problems that students can experience in real life. In the light of the instructional design they created, it was stated that the abstract functions and their graphics are an important structure that acts as a bridge between the context problems that need to be solved and the calculation operations in the formal structure that need to be developed. They also stated that using context problems enabled students to increase their experiential realities.

In 2003, in the study entitled "The didactical use of Models in Realistic Mathematics Education: An Example from a Longitudinal Trajectory on Percentage," Van Den Heuvel-Panhuizen aimed to describe how Realistic Mathematics Education

(RME) in the Dutch mathematics education approach was used to reveal students' development in their understanding of mathematics. The study focused on the use of bars designed to measure the longitudinal trajectory on percentages for the Mathematics in Context course at the middle school mathematics level in the American education system. It is stated that the use of this model contributes to the development of both the education system and learners. As a result of this study, Van Den Heuvel-Panhuizen stated that students gradually switched to formal mathematics by making mathematical inferences with abstract thinking instead of using concrete materials to draw or measure the percentage in a problem.

Van Putten, Van den Brom-Snijders and Beishuizen conducted a study entitled "Progressive Mathematization of Long Division Strategies in Dutch Primary Schools" in 2005. The solution of the long division operations within the framework of RME approach in the Dutch education system is divided into two categories. Schemes are used in one of these categories and number relationships are used in the other. At the beginning of the study, explanations were made to the students about the division operation, then, the long division and the division without remainder operations were explained. After 5 months from the beginning of the study, it was observed that the students mostly used the schema method for the long division operations. As a result of this study, attention was drawn to the effectiveness of the RME approach with the development and achievement of strategies on division operations.

Hough and Gough (2007) conducted a study entitled "Realistic Mathematics Education" on the testing of a teaching approach that uses context problems to help students understand mathematics. The aim of the study is to examine the RME approach in detail on a specific topic. During the study, students were enabled to transition from informal strategies to formal strategies with various exercises. At the end of the study, the researchers stated that the RME approach contributed to student development with a different pedagogy, mathematics became more meaningful to the students with the RME approach and that the self-confidence of the students increased with this approach, and that the positive agents were felt clearly within the scope of this project.

Anwar, Budayasa, Amin, and Haan (2012), in their work titled "Eliciting Mathematical Thinking of Students through Realistic Mathematics Education," focused on the instructional activities developed and implemented on the addition operations in fractions at the 4th grade in Indonesia. In addition, they aimed to increase the interest of the students who participated in the course with the instructional design created with the RME approach. During the study, responses of the students to contextual problems were shown and discussed. The researchers also stated that to reveal students' existing prior knowledge and direct them to different concepts were effective in order to strengthen their mathematical understanding skills, and they also tried to reveal the role of RME approach in providing this.

Stemn (2017), in his study titled "Rethinking Mathematics Teaching in Liberia: Realistic Mathematics Education," stated that the concept of division does not mean to share money or an item equally for some African cultures, and how an item is shared can

vary depending on the ages of the participants. This study describes the use of the Realistic Mathematics Education approach to teach equitable sharing of division problems related to everyday life involving money in 3rd grade in Liberia. In the study, it was stated that the students who were used to traditional teaching methods became more active participants and creative by learning with the RME model.

As it is seen in the studies briefly explained above, most of them mainly focused on developing instructional design within the framework of RME approach. The studies that were mostly designed as qualitative studies included how RME was used, how students developed in certain subjects within the framework of RME, how the process progressed, and how educational activities developed.

When the popularity of student-centered teaching approaches in the education system increased, the RME approach has also become more interesting. In the literature, it can be seen that the fact that students see that the taught contents may be situations they may encounter in their real life, in other words, feel that they may need the taught contents, is an important factor that enables them to realize a more meaningful learning. In this study, the researcher aimed to enable students to see the link between mathematics and their real lives by creating problems in real life context so that students can learn mathematics more meaningfully.

In addition, when the design-based studies are examined, it is seen that STEM studies are mostly conducted in the field of science education. The 2 studies below can be given as an example for this subject.

Gülhan and Şahin (2016) conducted a mixed research design with two 5th grade students studying at a secondary school in Istanbul in 2014-2015 about the effect of Science, Technology, Engineering, and Mathematics integration (STEM) on the perception, attitude, conceptual understanding and scientific creativity of 5th grade students. The study results found that the effect of STEM activities on 5th grade students' perceptions about STEM fields is generally positive and that it positively affected their perceptions towards the engineering profession. It has also been found that it positively influenced students' attitudes towards STEM fields and it generally increased their desire to choose STEM field professions; and it has shown a positive effect on improving their conceptual understanding regarding the field of science. It has been concluded that STEM activities have a limited effect on students' scientific creativity in terms of individual development, and it is more effective in the development of the highest level of creativity, the level of reflective thinking.

Bozkurt Altan, Karahan (2019), in his study titled "Student and Teacher Evaluations about Design-Based Science Education", aimed to determine the student evaluations for the "Heat Insulation is a Gain for Country" activity prepared based on "Design-Based Science Education" (DBSE) along with the opinions of the science teacher who performed the application about the application experience. The research was conducted with 32 6th grade students and 1 teacher. The students described the Design-Based Science Education process as a learning provider, as well as relevant to daily life, interesting and motivating. The teacher who performed the application also evaluated

the DBSE process positively as it is real life preparer, supportive for them to realize the engineering design process and motivating for them to learn.

4. Material and Methods

This section includes study design, study group, data collection tool and stages of the study, data collection, data analysis.

4.1 Study Design

The research is designed as action research which is one of the qualitative research types. Berg (2001) classified action research as three types. These are technical/scientific/collaborative, practical/ mutual collaborative/ deliberative, and emancipating/enhancing/critical actions (Yıldırım & Şimşek, 2011). Collaborative action research was used in this study. *“The goal of this approach is to test or to evaluate a particular application based on a pre-specified theoretical framework. For this purpose, there is an intense interaction between the researcher and the practitioner about the application process”* (Yıldırım & Şimşek, 2011, p.296).

4.2 Study Group

The study was conducted at Mehmetçik Imam Hatip Secondary School in the district of Güngören, Istanbul in the 2017-2018 academic year, for a total of 4 weeks, in March and April. The study group of the research consisted of 30 7th grade students. In addition, since participation in the study was on a voluntary basis, the number of students participating in each activity varied, but the study was conducted with approximately 20 students. Participants were selected using the convenience sampling method.

In the study, mathematics activities including real life examples, focusing on the subject of angles, expecting students to design products were prepared by taking expert opinion within the framework of Realistic Mathematics Education were applied to the students.

4.3 Data Collection Tool

4 activities, which were created by taking the opinions of 3 experts, 1 teacher with doctorate degree, 1 associate professor and 1 teacher, were used as data collection tools in the study. The activities created were prepared within the framework of the Realistic Mathematics Education approach and were applied to the students once a week for 4 weeks. In each activity, a relationship was established between real life and the subject of angles. In the activities, students were asked to design that include the subject of angles within the framework of the activities. Electronic portfolio was used during the application and students' responses to the activities were collected on the electronic portfolio. Edmodo software, which offers an interactive classroom environment that is free, simple enough for students to use, and where teachers can give quick feedback to students, was chosen as an electronic portfolio platform.

4.4 Stages of the Study

In the 1st week, Angry Birds activity was given to the students. In this activity, students were asked to be a game designer and to design a game including the subject of angles.

In the 2nd week, the students were given research questions about shadow in Sundial activity, and then they were asked to design their own sundials.

In the 3rd week, the Van Damme activity was held, and the students were first asked to watch the Volvo Trucks commercial in which Van Damme acted, and then the students were also asked to design their own commercial films in this direction.

In the 4th week, in the Tangram activity, students were first told to search what tangram was, and then they were asked to create their own geometric puzzles with rules like tangram.



Figure 1: Activity flow chart

The activities prepared were given to the students regularly every week according to the flow chart given in figure 1. In the first activity, students were asked to design a game using the subject of angles. The game of Angry Birds was introduced to the students as an example, and they were asked whether they had noticed that angles were used in the game. Most of the students stated that they did not notice that mathematics was used in a game. Thereby, the study was started to be implemented by showing the students that mathematics was also used in real life, and the students' attention was attracted to mathematics in real life.

In the 2nd activity, students were asked how the position and length of our shadows change. Students were asked to create sundials after they had noticed that our shadows changed depending on the angles of the rays coming from the sun. The students were in contact with their classmates while creating sundials and had the opportunity to get help from each other.

In the 3rd activity, a commercial film in which the topic of angles was used had been watched by the students and they were asked to design another commercial film using the subject of angle. Students produced many different commercial film ideas. Each response from students was analyzed under subheadings, as in other activities.

In the 4th and last activity, Tangram, students were asked to create the given tangram shapes and then to create other puzzles by using geometric shapes.

4.5 Data Collection

Selected as an electronic portfolio, Edmodo software, was used in a 7th grade level at the secondary school selected during the stage of implementation of the activities and collection of the feedback. On the Edmodo online platform, students had the opportunity

to communicate with researchers and their classmates outside of class hours. With this way, their social skills were also developed.

4.6 Data Analysis

The activities that will enable students to design products are as follows;

- Angry Birds activity to design games about the angles,
- Sundial activity to design a sundial,
- Van Damme activity to design a commercial film,
- Tangram activity to design puzzles.

The responses of the participants to the activities were examined under the sub-headings created by taking the opinions of 3 experts, 1 teacher with doctorate degree, 1 associate professor and 1 teacher, and descriptive analysis, one of the qualitative research methods, was performed. The number of subheadings varied for each activity and was evaluated according to yes-no and high-medium-low levels. These levels were categorized as Yes is 4 points, no is 0 points, high is 4 points, medium is 3 points and low is 2 points. Thereby, the evaluations were made over 56 points in total, as Angry Birds is 16 points, Sundial is 12 points, Van Damme is 12 points, Tangram is 16 points.

A sample evaluation table for the Angry Birds activity below.

Table 1: Evaluation criteria for the Angry Birds activity

Was the student able to design a game?	Yes		No
	Low	Medium	High
Was the student able to determine the game rules clearly?			
Was the student able to use the requested mathematical elements correctly?			
Was the student able to explain the game clearly by drawing or modeling?			
Originality level			

5. Results and Discussion

As a result of evaluating each activity under certain subheadings, this section of the study includes the tables of the frequencies and distribution percentages of the students, the interpretations of the tables and the examples selected from the student works.

In addition, the abbreviations used in the tables are as follows; C: Classification, f: Frequency, %: Percentage.

While examining the level of originality, the number of participants varied in each activity, but the responses given by an average of 15 students participating in the activity were compared with the responses of their other friends. And if less than 3 or less than 3 people made similar designs, it was evaluated at a high originality level, if similar designs were made between 4-6 people, it was evaluated at medium level, and if similar designs were made by more people, it was rated low.

5.1 Findings Obtained from the Angry Birds activity

This activity was held with a total of 22 people.

Table 2: Frequency distribution results and percentages according to subheadings determined within the scope of Angry Birds activity

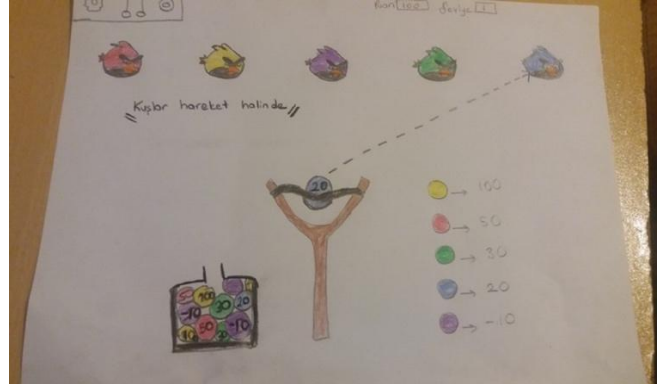
Sub-headings	C	f	%
Was the student able to design a game?	Yes	20	91
	No	2	9
Was the student able to determine the game rules clearly?	High	7	35
	Medium	4	20
	Low	9	45
Was the student able to use the requested mathematical elements correctly?	High	7	35
	Medium	7	35
	Low	6	30
Was the student able to explain the game clearly by drawing or modeling?	High	10	50
	Medium	4	20
	Low	6	30
Originality level	High	8	40
	Medium	5	25
	Low	7	35

Note: Since the percentages are rounded in some subheadings in a few activities, the total is not 100.

As seen in Table 2, the activity performed was examined under 5 subheadings. It was observed that the vast majority (91%) of students (20 out of 22) who reached the activity through Edmodo were able to design games. Within the scope of the activity, students were asked to create a game that includes angles and give the rules of this game clearly, and student responses were grouped according to high-medium-low levels. The majority of the students (45%) were observed to be able to explain the game rules at a low level. This is thought to be due to the fact that most of the students prefer to show their designs by drawing. In other words, it is predicted that the students were unsuccessful in expressing the game rules clearly because they focused on drawing.

When examining whether they were able to use the requested mathematical elements correctly, it is seen that the students were distributed at similar percentages at high-middle-low levels. When considering the students' responses in the 4th subheading, which is whether the students were able to explain their games clearly by drawing or modeling, it was seen that half of the students participating in the activity were able to model or draw at a high level. Finally, when the originality levels of the students were examined for this activity, it was observed that the students showed a high level of originality (40%) with a slight difference.

The works of 2 students are given as an example below.



Oyunumuz uygun açığı bulup doğru rengi vurmakla alakalıdır. Kutuda bulunan renkli toplardan rastgele bir tanesini seçiyoruz. Seçtikten sonra topu sapanın yerleştirip ekranda uçan renkli angry kuşlarını seçtiğimiz topun ve kuşun rengine göre sapanın açısını ayarlayıp vuruyoruz. Sarı top=100 puan Kırmızı top= 50 puan Yeşil top= 30 puan Mavi top =20 puan Mor top= -10 puan dir. Açığı doğru ayarlayıp rengine göre vurursak topların üzerindeki puanı alıyoruz, vuramassak -10 puan hanemize yazılıyor. Toplam 5 top atma hakkımız var. 100 puanı alan diğer seviyeye geçiyor, alamayan ise başa dönüyor. Seviyeler ilerledikçe oyun zorlaşıyor. oyun toplamda 10 seviyeden oluşmaktadır.

Figure 2: Illustration and rules of the game designed by the student with code E15
(The student designed a game that aims to shoot the birds choosing the correct angle)



BALPATAÇ OYUNU
Balpataç oyununda açığı çok iyi ayarlamamız lazım aslında bir tür balon patlatmaca oyunu. Nasıl oynandığını öğrenelim. Önümüzde bir sürü top var ama bazıları ateşten bazıları ise sudan yapılmış ve bir de kendi topumuz var bu topları suyla yapılmış olan topları vurmaya çalışacağız eğer ateşten yapılmış topu vurursak en başa döneceğiz e tabii ateşten yapılmış topa vurmamak için açığı iyi ayarlamak gerekiyor. (kırmızı top, ateş mavimsi top ise sudur.)

Figure 3: Illustration and the game rules designed by the student with code E3
(The student designed a game in which the player shoots the water balloons and does not shoot the fire balloons. While shooting them, the player should find the correct angle)

Two students with codes E15 and E3 designed 2 games on throwing off something similar to the Angry Birds game using the angles and they determined the rules of their games in the blue background.

Besides the students' works given above, other students also similarly preferred to create their designs mostly by drawing. In fact, most of them participated in the activity

by drawing only, and as shown in the table, it was observed that the majority was at a low level in terms of clearly determining the game rules.

5.2 Findings Obtained from the Sundial Activity

This activity was held with a total of 20 people.

Table 3: Frequency distribution results and percentages according to subheadings determined within the scope of sundial activity

Sub-headings	C	f	%
Was the student able to make the sundial?	Yes	16	80
	No	4	20
Was the student able to answer the questions correctly?	High	6	30
	Medium	10	50
	Low	1	5
Was the student able to answer the research questions correctly?	High	9	45
	Medium	5	25
	Low	3	15

In this activity, 4 students answered the research questions even though they did not make the sundial, and 3 students did not answer the research questions even though they made the sundial.

In the 2nd activity, the students were given a worksheet through the Edmodo program and they were asked to solve the questions on the worksheet by doing research, and in the second part of the activity, the students were asked to make their own sundial. As can be seen in Table 3, the students' works for this activity were examined under three subheadings: being able to make sundials, answering questions correctly and doing research questions. The students have reached 80% success in making sundials. When examining the level of solving the research questions correctly, it was observed that half of the group intensified at a medium level. It is thought that the reason for the group's doing a good research may have been their receiving and responding to the activities on the online platform and being intertwined with the internet. Finally, when doing research skills were examined, almost half of the group (45%) were observed at a high level.



Figure 4: Sundial designed by students with codes E5 and E7

Photographs of sundials that the students with codes E5 and E7 created in the group in which the electronic portfolio is used are given as an example above.

5.3 Findings Obtained from the Van Damme Activity

This activity was held with 15 people in total.

Table 4: Frequency distribution results according to subheadings determined within the scope of Van Damme activity

Subheadings	C	f	%
Was the student able to design a commercial?	Yes	15	100
	No	0	0
Originality Level	High	11	73
	Medium	2	13
	Low	2	13
Was the student able to use the mathematical concepts and knowledge about the topic correctly?	High	10	66
	Medium	5	33
	Low	0	0
Was the student able to explain her/his opinion about commercial design clearly?	High	8	53
	Medium	4	27
	Low	3	20

In the 3rd activity, the students were asked to watch the commercial film played by the actor named Van Damme. Then, the students were expected to design a commercial using the subject of angles. As it is seen in Table 4, this activity was examined under 4 subheadings. Participants were 15 students in the study. The majority of the group (73%) showed a high level of originality. When the correct use of mathematical elements on the subject was examined, it was seen that two-thirds of the group were able to use mathematical concepts at high level and the remaining one-third at medium level. When examining their level of expressing their ideas about commercial designs clearly, more than half of the group (53%) was seen to have intensified at a high level.

As seen in Figure 5., the student with code E9 designed a gymnastic course commercial by using the photograph of a man who can stretch his legs 180 degrees within the scope of Van Damme commercial design activity.



Ben olsam bir jimnastik kursu için reklam yapardım daha iyi nasıl esnek olabileceğimizi esnek olunca neler yapabileceğimizi göstermek.Eğer bu kursa giderse bacaklarını 180°açabilceğini göstermek isterdim

Figure 5: The commercial designed by the student with code E9 and its description (The student, who designed his own commercial inspired by the Van Damme commercial, advertised a gymnastics course by showing a photograph of an old man's stretching his legs 180 degrees)

5.4 Findings Obtained from Tangram Activity

This activity was held with 16 people in total.

Table 5: Frequency distribution results according to subheadings determined within the scope of Tangram activity

Subheadings	C	f	%
Was the student able to design a puzzle?	Yes	12	75
	No	4	25
Was the student able to form the requested tangram shapes?	High	0	0
	Medium	7	50
	Low	7	50
Was the student able to determine the game rules clearly?	High	2	17
	Medium	3	25
	Low	7	58
Was the student able to use the requested mathematical elements correctly?	High	2	17
	Medium	7	58
	Low	3	25

In the 4th activity, the students were told what tangram was, they were asked to do research to get more information, and then they were asked to create the given tangram shapes. In the last part of the activity, students were asked to design their own puzzles using geometrical objects. As is seen in Table 5, activity has been examined under 4

subheadings. Considering the percentage of puzzle design, it was seen that the group was successful in designing games to a great extent (75%). In forming the requested tangram shapes, the students were equally distributed between the medium and low levels. When the level of determining the rules of the puzzle is examined, it is observed that the students show a low majority (58%). It is thought that the students remained at a low level in clearly explaining the rules of the puzzle, since they preferred to show their puzzles by drawing instead of explaining them in writing. When their ability to use the requested mathematical elements correctly is examined, it is seen that more than half of the students (58%) intensified at medium level.

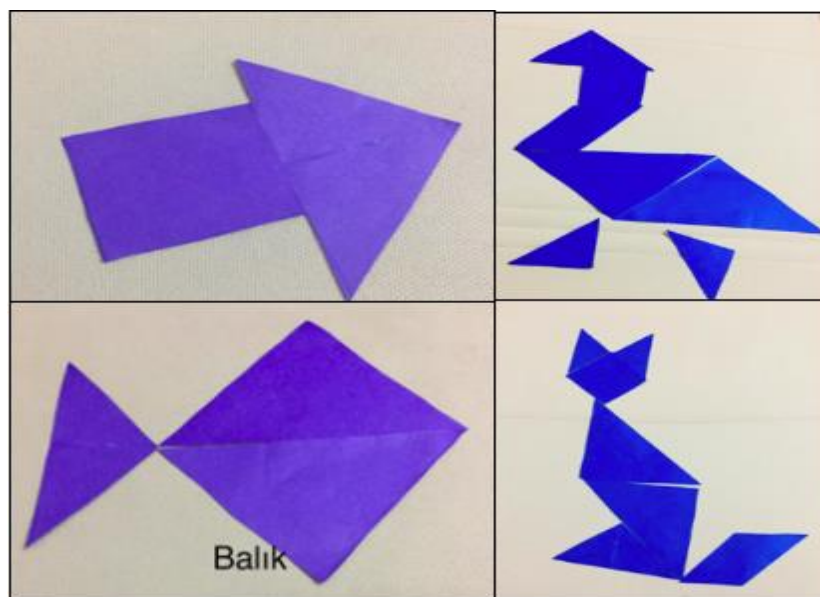


Figure 6: Tangram work of the student with P6 code

Figure 6 shows the work of the student with P6 code who created the shapes given in the Tangram activity with his/her own tangram pieces.

In the study, it was aimed to evaluate the student outcomes based on certain sub-headings created after obtaining expert opinion by applying the activities prepared within the framework of realistic mathematics education. As seen in the findings section, the determined sub-headings are given in separate tables for each activity, and the sub-headings created are categorized under 5 main headings: designing products, expressing the mathematical opinions clearly, research skills, using mathematical knowledge, and originality.

Considering the heading of product design, which is the first main heading, there are sub-headings of designing games, making sundials, designing advertisements, and designing puzzles. Since participation in the activities is based on volunteerism, while examining these subheadings, evaluation could only be made over the number of students participating in the activities. It was observed that the students participating in the activity were able to design products at the rates of 91%, 80%, 100% and 85%, respectively.

The 2nd main heading, expressing mathematical ideas clearly, includes the subheadings of clearly determining the rules of the game, explaining the game clearly by drawing or modeling, clearly expressing the idea of the commercial design, and determining the rules of the puzzle clearly. Students' answers were evaluated as high-medium-low level based on these headings. Considering the main topic of expressing mathematical ideas in general, in the Angry Birds activity, it is seen that while students explain their games they designed by drawing at a high level, they can clearly express their ideas of commercial design at a high-level majority in the Van Damme activity. Finally, in the Tangram activity, it is seen that the students concentrated at a low level in the subheading of clearly determining the rules of the puzzle. It is thought that the reason for this is the fact that students show their puzzle designs with drawings and find it unnecessary to explain the rules of their puzzles in writing. Additionally, it is observed that students can express their mathematical ideas clearly because they can visually support their ideas about commercial design in the Van Damme activity, as they study on the online platform Therefore, Edmodo software is thought to have a positive effect on students, since it facilitates the use of visual materials.

In the 3rd main heading, research skills, there is a subheading of solving the research question. On the basis of this heading, the students' responses were evaluated as high-middle-low level. In the Sundial activity, students intensified at a high level of 45% in the criterion for solving the research question. In this subheading, it is thought that there is a big difference between the levels, and the reason for it was the fact that the research question in the activity required doing research on the internet, and the use of Edmodo facilitated internet access for students.

The 4th main heading contains the subheadings of being able to use mathematical knowledge, being able to use the requested mathematical elements correctly, to answer questions correctly, to use the mathematical concepts and information on the subject correctly, to create the requested tangram shapes, and to use the requested mathematical elements correctly. On the basis of these headings, students' responses were evaluated as high-middle-low level. The levels that students show majority differed in terms of subheadings and there was no common tendency.

In the 5th and last main heading, originality, the originality levels of the students' works were examined through two activities and the student works were evaluated as high-medium-low levels. In the Angry Birds activity, the originality level intensified at a high level of 40%. In the Van Damme commercial design activity, this level intensified at a high level of 73%. That the originality level in the Angry Birds activity was less is thought to be due to the fact that students were at the beginning of the process of getting used to the activities, as it was their first activity. The students became more successful in producing more original ideas in the 3rd activity, the commercial design activity.

6. Conclusion

Many advantages of using electronic software have been seen during the implementation of the activities. For example, in the Sundial activity, students could have had difficulty in carrying their sundials to the classroom since they had to bring them to school, but with the activities carried out through Edmodo, the students did not have to carry their sundials, they just took photos of them and uploaded them to the system. Students using Edmodo can access their online classroom with their personal passwords and can keep their work there for a long time. In addition, the students had the opportunity to enter the system and update their assignments until the end of the homework deadline. This feature of Edmodo can provide a lot of advantages to the students while designing products. They were able to communicate with the researcher and get help on the online platform outside of the school. They were able to enrich their activities by visual materials, share their work on Edmodo with their families, and have the opportunity to communicate with their peers through Edmodo and improve their social skills. On the other hand, the students had some difficulties such as logging into the system, uploading the homework, and seeing the details of the assignment at the beginning of the application, since they did not have sufficient technical knowledge about the use of Edmodo. It can be said that the advantages and disadvantages of using the electronic platform mentioned here are in parallel with the information given in the literature review of the study.

Finally, parallel to the study of Bozkurt Altan, Karahan (2019) in the literature, and by looking at the results of this study, it can be concluded that the educational process which is carried out with design-based activities provides learning, and is relevant to daily life, is interesting and is motivating. The usefulness and ease of use of technology by educators is drawn attention in the study of Gokuladas (Gokuladas, 2020), conducted on online education. Proficient counseling and training programs can help teachers to act more comfortably in technology-supported education and overcome difficulties. The integration of face-to-face teaching with technology and online approaches also help teachers manage design-based activities in a more effective way.

7. Recommendations

- Studies may be conducted to determine the effects of the use of online software platforms on students' academic achievement, self-evaluation and creativity.
- General frameworks for practitioners can be developed in order to ensure that a similar instructional design can also be conducted effectively for other disciplines.

Conflict of Interest Statement

The authors declare no conflicts of interests.

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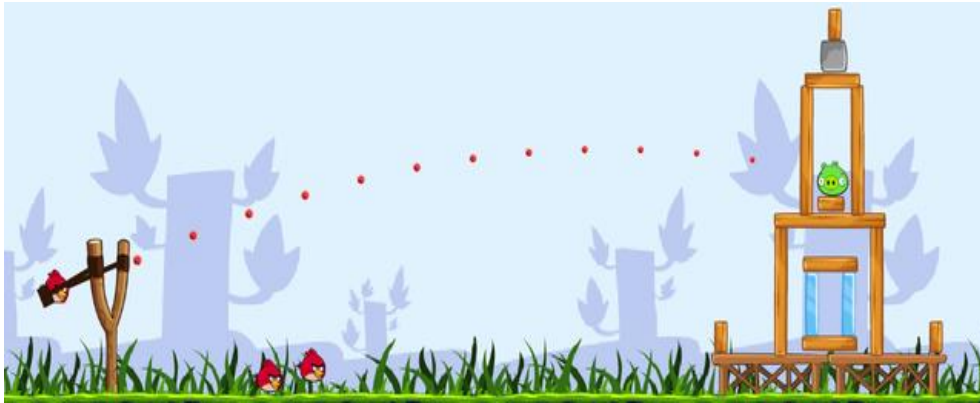
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Appendices

A. Angry Birds Activity

Student name:

Student number:



Have you ever played the Angry Birds game? The aim of this game is to try to knock over the boxes by throwing birds from different angles.

The designers of this game may have thought that such a game would be favorable in the market, based on the instinct of children to “throw off things”. If you were a game designer and designed a game and wanted to use angles in it, what kind of game would you design and what would be its rules?

(You can explain it by drawing.)

B. Sundial Activity

Student name:

Student number:



C. Shadow Game

Our shadow length varies at certain times of the day on sunny days. For example, have you ever noticed that our shadow length differs in the morning hours and in the noon hours? Why do you think this may happen?

.....
.....

When do you think our shadow will be the lengthiest? Why is that?

.....
.....

When do you think our shadow will be the shortest? Why is that?

.....
.....

Do you think we can predict what time of the day we are based on our shadow length? How?

.....
.....

What was done about this subject in ancient civilizations? Search for it.

.....
.....

How about creating a clock based on the position of the shadow?

You can create your sundial in different ways, either as described below or by searching from other sources.



Equipment: paper plate, pen or pencil, play dough

Steps:

- 1) Write the numbers from 1 to 12 at equal intervals on the back of the paper plate.
- 2) Open a small hole enough to fit a pen in the center of the paper plate.
- 3) Fix the pencil to the hole you drilled with the help of play dough. (You can insert the play dough on the invisible part of the plate.)
- 4) You can place your sundial in a sunny place according to the real time and monitor the positions of the shadow.

D. Van Damme Activity

Student name:

Student number:



Watch the Volvo Trucks commercial starring Van Damme (<https://goo.gl/RHo23S>). You can observe the transition of the angle of his legs from acute angle to obtuse angle and flat angle. This commercial sounds interesting to us because it is difficult for people to stretch their legs at 180 degrees, moreover, between trucks. If you were a commercial designer, in which commercial film would you have Van Damme act by using his 180 degree leg stretch skill? Why is that?

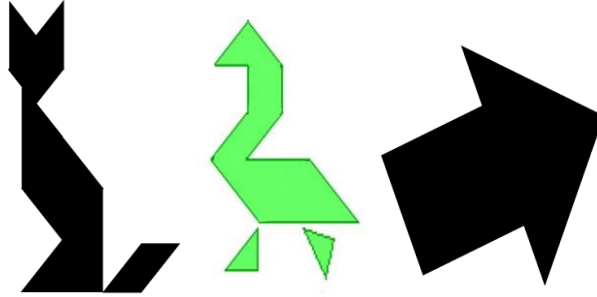
E. Tangram Activity

Student name:

Student number:

Do you know what tangram is? If you hear about it for the first time, you can do research about Tangram on the internet. Remember, the most important rule of Tangram is that each of the seven pieces should be used to form a shape and its pieces do not overlap.

Cut the tangram on the back page with scissors and try to create the following shapes. (Once you have created the shape, take a photo of it and print it, or show how you placed the pieces by drawing.)



So, if you wanted to create a puzzle using geometrical shapes, what shapes would you create? You can show it by taking its photos after drawing or making a model. Don't forget to explain the rules of your puzzle. You can use any geometrical shapes you want. Did you use angles while creating your puzzle? If your answer is yes, explain.

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