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*Research Article*

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## Investigating the Impact of Real-World Contexts on Geometry Learning and Student Perceptions

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### Abstract

This study aims to examine the change in the self-efficacy beliefs of secondary school students towards geometry after a specific pedagogical practice and investigate their views on the learning process and learning environment. In this approach, students engaged in activities that helped them connect their theoretical geometry knowledge to real-life situations. The students were required to actively participate in these activities such as taking pictures of geometric shapes they encounter in their daily lives and sharing them in a closed social learning environment with the appropriate tags. The research was carried out using the case study method. Various qualitative and quantitative data were collected through multiple record sources. Quantitative results show that the students' self-efficacy beliefs towards geometry were significantly higher after the pedagogical practice. Qualitative analyses were carried out to reveal students' perceptions of mathematics courses, their perceptions of learning activities, their views on the reflection process, their general evaluations, and the problems they experienced as a result of the learning experience. It was seen that the learning experience and learning environment were generally evaluated positively by the students and various contributions were expressed.

### Key Words

Authentic learning • Real-world contexts • Self-efficacy beliefs in geometry

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## Concepts

Mathematics is primarily sense-making and problem-solving activities related to the mathematical modeling of reality rather than abstract concepts and procedural skills that need to be mastered (Corte, 2004). We constantly need to use mathematics in our daily life during many activities such as measuring length or weight, calculating the total time for any action, or finding the most affordable product. “An individual's capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgments and to use and engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen” is called mathematical literacy (OECD, 1999). According to the results of the International Student Assessment Program (PISA) research conducted by the Organization for Economic Co-operation and Development (OECD), Türkiye ranked 42nd among 79 countries with an average of 454 in the field of “Mathematics Literacy” (MEB, 2019). The purpose of the PISA study is to evaluate students' ability to use and apply their knowledge and skills and their reasoning skills in situations they may encounter in real life (Aşkar ve Olkun, 2005). Similarly, in the Trends in International Mathematics and Science Study (TIMSS), Türkiye ranked 34th among 38 participating countries in terms of geometry achievement (Özdemir & Üzel, 2013). TIMSS evaluations categorize mathematical achievement into content domains such as numbers, algebra, geometry, measurement, data, and probability. In TIMSS 2023, Turkish 8th-grade students scored lower than the overall average in geometry, measurement, and algebra, with geometry and measurement having the lowest average among the mathematical domains. These findings indicate ongoing challenges in mathematics education and highlight the need for instructional approaches that better connect mathematical concepts with real-life applications (MEB, 2024). Many improvements in mathematics and other disciplines were made in 2005 in Turkish curricula for connecting information with real life, within the scope of 1-8 grade curricula (MEB, 2018). However, despite the revised and implemented curriculum, PISA and TIMSS results reveal proficiency in mathematics still needs to be improved.

Self-confidence, enjoyment, and anxiety toward math can influence a student's success in math, one of the most challenging subjects for students. “Self-efficacy belief strongly influences which activities individuals choose and how much effort they put into performing these activities and how much they try to cope with the challenges they face” (Bandura, 1977). For this reason, self-efficacy belief in any subject effects performance in that subject. There is considerable evidence in the literature revealing that there is a positive and significant relationship between students' self-efficacy beliefs towards mathematics and their academic success (Yang, Maeda & Gentry, 2024; Liu, Jong & Fan, 2024; Erdoğan, Baloglu & Kesici, 2011; Spence & Usher, 2007; Stevens, Olivarez, & Hamman, 2006; Khasawneh, Al-Omari & Tilfah, 2000; Kaln, 2010). For this reason, activities and practices should be designed to provide experiences that can improve learners' self-efficacy beliefs towards mathematics.

Ojose (2011) stated that an important part of mathematical literacy is using, doing, and recognizing mathematics in various situations and so the choice of mathematical methods and representations often depends on the situations in which the problems are presented. He also claimed that mathematics teachers often complain that students have difficulty applying the mathematics they learn in different contexts. One of the main reasons for this complaint is that mathematics, which consists of abstract contents such as rules and algorithms, is not transferred by embodying it in

real-life contexts. In the traditional mathematics teaching approach, first, the rules are explained by the teachers, then the solution methods of similar exercises are shown and then the student is asked to put these rules into practice (Ünal & Ipek, 2009). However, according to the results of numerous studies, students perform differently when faced with abstract and contextual computations for the same math demand (Boaler, 1993). Therefore, instructional design should incorporate concrete examples rather than presenting the rules abstractly to increase the likelihood that students will apply their mathematical skills outside of the classroom (Wubbels, Korthagen, & Broekman, 1997). In line with this, a key finding of recent research demonstrated that the use of the concrete-representational-abstract (CRA) instructional sequence is paramount for the effective teaching of mathematics, as it helps bridge the gap between abstract mathematical concepts and their practical applications (Mudaly & Naidoo, 2015). This approach ensures that students first interact with tangible representations, then progress to visual models, and ultimately transition to abstract notations, fostering a deeper understanding of mathematical concepts. Additionally, mathematics instruction should actively connect classroom learning to real-world contexts to enhance its relevance and applicability (Boaler, 1993).

According to Jonassen (1991), individuals build their understanding through active engagement, so learners should be encouraged to explore, articulate, and reflect on their learning through real-life, relevant, and authentic tasks. Similarly, the theory of Realistic Mathematics Education (RME) emphasizes building long-term mathematical understanding by grounding learning in realistic contexts (Gravenmeijer, 1994; Lange, 1996; Zulkardi, 1999). Student-oriented approach, real-life related scenarios, and exploratory activities form the core of the RME (Doorman, Heuvel-Panhuizen, & Goddijn, 2020, p.285). By using the RME, students can make sense of what they are doing, without memorizing rules and procedures. Real-life-related mathematics instruction would enhance students' interest in mathematics and help them to learn mathematics in-depth and permanently (NCTM, 2000).

The primary school mathematics curriculum covers several geometry topics. Geometry is a fundamental branch of mathematics that plays a crucial role in school curricula (French, 2004). It is a structured discipline that integrates visual representation with abstract reasoning, concrete intuition with general theories, and historical perspectives with contemporary applications (Duatepe-Paksu et al., 2022). According to Jones & Mooney (2003) developing fundamental visualization and spatial reasoning skills is crucial in today's increasingly visual world. By engaging with geometric concepts, students can enhance their spatial awareness and, in addition, strengthen their logical reasoning abilities while developing problem-solving strategies applicable to real-life situations (Jones & Mooney, 2003). According to Schwartz (2008), exploring geometry fosters students' ability to think critically and tackle mathematical challenges. Connecting geometry to daily life is essential for preparing individuals for real-world challenges, as it helps students interpret their surroundings by recognizing geometric shapes in nearly every aspect of their environment (Baykul, 1998). However, in many classrooms, including elementary schools, geometry instruction remains largely teacher-centered, relying on lectures rather than hands-on, contextual learning. As a result, students often take a passive role in the learning process instead of actively engaging with geometric concepts (Ahmad, 2021). According to Freudenthal (1987), geometrical experiences start with 'watching, acting, thinking and seeing' the surrounding environment in everyday life. So, geometry education should also be initiated with realistic problems and continue through exploratory activities (Doorman, Heuvel-Panhuizen, & Goddijn, 2020, p. 291).

With the developing technology in today's world, it has become easier to support learning in real-world contexts (Waycott & Kennedy, 2009). Web 2.0 technologies and tools enable individuals to be actively involved in content creation, produce information, collaborate, and share online without having advanced technology skills (Grosbeck, 2009). In the literature, the most often used Web 2.0 applications are multimedia-sharing platforms such as Instagram, Flickr, and Youtube to integrate formal knowledge in different courses with real life (Ractham, Kaewkitipong & Firpo, 2012; Burke, Snyder & Rager, 2009; Gray, Kennedy, Waycott, Dalgarno, Bennett, Chang & Krause, 2009; Waycott & Kennedy, 2009).

This is due to the fact that they are familiar platforms that users already use in their daily lives, as well as they are very useful for sharing content and obtaining user opinions. However, since they are not primarily designed as learning environments, they are not convenient for several learning/teaching processes such as following a specific plan, doing learning activities, and assigning homework. Social learning platforms contain various features for learning/teaching activities such as presenting activities, assigning tasks or questions to students, or giving feedback. They also let users create groups, add descriptions and tags, comment on photos, and have several interactive features. Studies on social learning environments have increased especially since 2014 and Edmodo is one of the prominent platforms (Polat & Saban, 2019). Edmodo is a free social learning network that enables teachers to create an online classroom community and allows students to connect and work with their classmates and teachers anytime, anywhere.

To increase mathematics proficiency, having a positive perspective toward the lesson is considered a prerequisite. Following this prerequisite, being able to understand and use real-world mathematics brings real success in mathematics. For that reason, designing effective pedagogical practices that demonstrate how to use mathematics in real-life contexts is important. A social learning environment could be integrated into this pedagogical practice to provide opportunities for students to reflect on their use of formal knowledge outside of the classroom and interact with each other. Furthermore, gathering empirical evidence on this pedagogical practice is needed. So, this study aims to provide a useful reference point for practitioners by providing a specific pedagogical practice that focuses on relating mathematics in the classroom to the real world and contributing to the existing research by examining real classroom experience.

### **Rationale and Purpose of the Study**

This study aims to examine the change in the self-efficacy beliefs of secondary school students towards geometry as a result of the specific pedagogical practice and investigate their views on the learning process and learning environment.

## **Method**

### **Research Design**

This study employed a case study methodology. Quantitative data, specifically students' geometry self-efficacy, was collected using a single-group pre-test/post-test quasi-experimental design to determine the intervention's

impact. The qualitative component involved analyzing student interactions with the system, responses to reflection questions, data from interviews, and observation notes, alongside information gathered from questionnaires.

### **Participants**

Study participants are 6th-grade students at a public school in Ankara, Türkiye, selected through convenience sampling. Initially, 43 students volunteered to participate in the study. However, twenty-eight students participated in the intervention, 13 of whom were girls and 15 of whom were boys, but only 19 completed questionnaires and interviews.

### **Learning Environment**

Researchers used Edmodo to design a specific learning environment and they revised it based on the opinions of five experts in the field. Through this design, the students were given activities that would enable them to relate their theoretical geometry knowledge to real-life situations. The students were required to take pictures of geometric shapes they encounter in their daily lives, such as squares and rectangles, and share them in a closed Edmodo group with the appropriate tags with their friends. In addition, the students were asked to make the desired calculations about the geometric shapes they uploaded to the system, answer the discussion questions asked every week, go over the answers given by their friends, add a comment explaining what they agreed or disagreed with and why, and to answer the reflection questions about the activities they carried out that week. In addition to this, students were required to classify triangles, geometric objects and flag examples posted by their peers and share their favorite pictures along with their justifications.

### **Research Instruments and Processes**

Six different data collection instruments were used to gather the qualitative and quantitative data in this study. These instruments are self-efficacy scale for geometry, questionnaires, interview questions, reflection questions, students' interactions with the system, and observation notes.

#### **Self-efficacy Scale for Geometry**

The self-efficacy scale for geometry, developed by [Cantürk-Günhan & Başer \(2007\)](#), consisted of 25 items and 3 sub-dimensions, was used. The use of geometry knowledge, positive self-efficacy views, and negative self-efficacy beliefs are the three subdimensions of the 5-point Likert scale. A higher score on the scale reveals a higher level of self-efficacy regarding geometry.

#### **Questionnaires**

The students were asked open-ended questions before ( $f=4$ ) and after ( $f=30$ ) the implementation. The purpose of these questions is to determine how much students associate the objects they see or situations they encounter in daily life with the subjects they study in the mathematics course; to obtain their opinions on the social interaction and reflection process within the scope of the pedagogical practice, and to obtain their general evaluations of the pedagogical practice.

### **Interview Questions**

Interviews were conducted with some of the students to learn more about their perspectives on the social interaction and reflection process within the context of the pedagogical practice, as well as their overall impressions of the pedagogical practice.

### **Reflection Questions**

Beginning with the first week of the pedagogical practice, three reflection questions were posed to the students after they completed the activities. The purpose of these questions is to allow students to reflect on their learning experiences while completing tasks that week, allowing them to evaluate both the activities and their performance in the activity.

### **Students' Interactions with the System**

Interactions of students with the system consist of their behaviors on the Edmodo platform. These behaviors include photos they uploaded to the system, likes they gave, comments they wrote and answers they gave to discussion questions, comments they made on their friends' answers, and tasks they uploaded.

### **Observation Notes**

Because the application is conducted online, the researcher could only observe the participants' movements on the social learning platform. The researcher is both an active member of the group and an observer because she is the one who both presents the activities and assists the participants with any hardware or platform-related issues they may encounter.

### **Implementation Process**

Throughout the 7-week implementation, a short message was sent to students via Edmodo on the first day of each week, describing the activities to be completed that week (Figure 1). Students completed the necessary tasks within the scope of these activities during the week. For example, photographing the object(s) encountered in daily life that has the geometric shape discussed in that week's event and sharing with appropriate tags in a closed group created in the Edmodo system (Figure 2). During the adaptation week, students were shown an example of the activities they would do during the practice (sharing photos, tagging, filling out a Word template, and answering discussion questions) to help them adapt to the social learning platform. Table 1 shows all of the activities involved in the implementation process.

Table 1

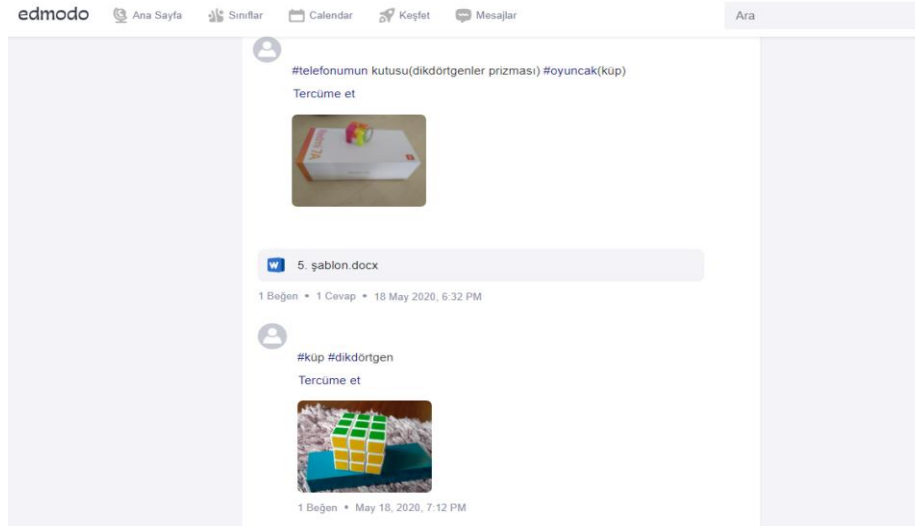
*Activities in the implementation process*

| Weeks           | Activities                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Adaptation Week | <ul style="list-style-type: none"> <li>• Filling out and uploading the resume template related to the mathematics course to the system</li> <li>• Taking a picture of a hobby and uploading it to the system with the appropriate tag and description</li> <li>• After answering the question posed in the discussion section, they should go over the answers given by their friends and add a comment explaining what they agreed or disagreed with and why.</li> <li>• The question was "Is it boring that you have to stay at home because of the Covid-19 pandemic? Is there anything you gained from the time you had to spend at home? "What exactly are these?"</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Week 1          | <ul style="list-style-type: none"> <li>• Photographing a measurable example of a square or rectangle that they find in everyday life and uploading it to the system with appropriate tags.</li> <li>• Measuring the side lengths with the help of meters. Calculating area and perimeter.</li> <li>• Photographing a measurable triangle sample that they encounter in daily life and uploading it to the system with appropriate tags.</li> <li>• Side lengths are measured using meters. Area and perimeter calculation</li> <li>• The students were asked, "Which different geometric shape formula could be used to calculate the area of a triangle?"</li> <li>• After answering the question posed in the discussion section, they should go over the answers given by their friends and add a comment explaining what they agreed or disagreed with and why.</li> <li>• The following questions were asked in the discussion section "How does knowing a shape's area help us in real life? What, for example, is the advantage of calculating the area of a rectangular gymnasium in real life?"</li> </ul> |
| Week 2          | <ul style="list-style-type: none"> <li>• Choose three of your favorite square, rectangle, and triangle photos from your friends' photos uploaded the previous week and explain why.</li> <li>• Classification of the triangle photos their friends posted the previous week by side lengths (equilateral, isosceles, and scalene triangles).</li> <li>• Classification of the triangle photos their friends posted the previous week by angles (acute angle, right angle, and obtuse angle).</li> <li>• The following questions were asked in the discussion section after watching the video your teacher uploaded: "Is it possible to get equal triangles by folding the whole rectangular paper (A4) that we had at the beginning? Why?", "How did we make the square part of the rectangle from a rectangular piece of paper?"</li> </ul>                                                                                                                                                                                                                                                                       |
| Week 3          | <ul style="list-style-type: none"> <li>• Examining different countries' flags that contain geometric shapes on the internet, saving photos of the two most different flags to the computer/phone, and uploading them to the system with the appropriate tags.</li> <li>• Writing which country the flag belongs to and what geometric shapes are in it in the description section.</li> <li>• To like the two most interesting flag photos uploaded by classmates, click the "Like" button.</li> <li>• Grouping the country flags in the "Flag photos.pdf" file by geometric shape and placing them in the two tables in the "4.template.docx" file.</li> <li>• Grouping the country flags in the "Flag photos.pdf" file by positions of geometric shapes on the flag and placing them in the two tables in the "4.template.docx" file.</li> <li>• After answering the question posed in the discussion section, they should go over the answers given by their friends and add a comment explaining what they agreed or</li> </ul>                                                                                 |

|        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Week 3 | <p>disagreed with and why. The following questions were asked in the discussion section “Were there any points in the previous activity when you were unsure about which group to place the flags in?”, “Which geometric shape do you see the most in your surroundings?” Can you give some examples of where you’ve seen this shape? Why do you believe you see this form the most?</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Week 4 | <ul style="list-style-type: none"> <li>• Photographing an interesting example from a set of geometric objects (square prism, rectangular prism, and cube) that they come across in their daily lives and uploading it to the system with the appropriate tag.</li> <li>• Writing the number of faces, edges, and vertices of the object in the description section.</li> <li>• The students were asked, “What geometric shapes do you see in the interior sections of the object you’re photographing?”</li> <li>• Stacking and photographing any two square prism, rectangular prism, or cube examples they come across in their daily lives. Uploading to the system with appropriate tags.</li> <li>• Measuring the side lengths of geometric objects with meters. Making volume calculations.</li> <li>• Along with the photo, filling out the file “5.template.docx” and uploading it to the system.</li> <li>• In the file “template.docx,” doing the following for both geometric objects: <ul style="list-style-type: none"> <li>• Writing the names of geometric shapes on the object’s faces</li> <li>• Writing the lengths of edges,</li> <li>• Writing the volumes of each object’s</li> <li>• Writing the total volume of the two geometric objects.</li> </ul> </li> <li>• After answering the question posed in the discussion section, they should go over the answers given by their friends and add a comment explaining what they agreed or disagreed with and why. The following questions were asked in the discussion section “What kinds of geometric patterns do you see in your environment?”, “Which geometric shape appears the most frequently in these patterns? What do you think is the cause of this?”</li> </ul> |
| Week 5 | <ul style="list-style-type: none"> <li>• Choosing three of their favorite photos from the cube, square prism, and rectangle prism photos their friends uploaded the previous week and explaining why they like them.</li> <li>• Classification of the object photos their friends posted the previous week by geometric type (cube, square prism, or rectangular prism).</li> <li>• Classification of the object photos their friends posted the previous week by the material they’re made from (wood, glass, plastic, etc.)</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Week 6 | <ul style="list-style-type: none"> <li>• Examining microscopic images of plant, animal, and fungal cells on the internet and saving photos of the cells with geometric shapes.</li> <li>• Uploading photos of the cells with geometric shapes to the system with appropriate tags and in the description part, describing what the cell belongs to (for example onion shells) and which geometric shapes it contains.</li> <li>• Examining the cell photos their friends uploaded in the first activity this week and choosing three of their favorite photos and explaining why they like them.</li> <li>• After answering the question posed in the discussion section, they should go over the answers given by their friends and add a comment explaining what they agreed or disagreed with and why. The following question was asked in the discussion section “Do you encounter mathematics and geometry in other courses and how do you use them? Can you give an example?”</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |



**Figure 1.** An explanation post shared by the teacher on Edmodo about the activities planned for the fifth week



**Figure 2.** Examples of student posts uploaded to Edmodo as part of the fifth-week activities

### Data Analysis

In order to examine the change in the self-efficacy beliefs of the participants towards geometry, the total score obtained from the Self-efficacy scale for geometry before and after the implementation was analyzed by the Wilcoxon Signed Ranks test. Furthermore, the Wilcoxon Signed Ranks test was used to analyze the scores obtained from the Positive Self-Efficacy Beliefs and Negative Self-Efficacy Beliefs dimensions of the same scale, and the Dependent Samples t-test was used to analyze the scores obtained from the Use of Geometry Knowledge sub-dimension.

To obtain students' experiences in the social learning environment as well as their perspectives on the learning process and learning environment, data collected through interviews, questionnaires, reflection questions, and

qualitative data obtained from students' interactions with the system were analyzed using content analysis. All qualitative data were carefully read and coded, and similar data were brought together within the framework of certain themes, and the frequencies of these themes were determined.

According to the internal consistency analysis, Cronbach's alpha values of the Geometry Self-Efficacy Scale were 0.87, 0.67, and 0.78, respectively. The scale's overall reliability coefficient was determined to be 0.90. Confirmatory Factor Analysis (CFA) was used to determine whether the scale used in this study adhered to the original factor structure. Chi-square, p-value, degrees of freedom ( $\chi^2/\text{df}$ ), root mean square error of approximation (RMSEA), and standardized root mean square residual (SRMR) values were examined to determine the model's suitability (Table 2). Except for the small difference in the SRMR value, all values indicate that the scale is a suitable measurement model because the 2/df value is less than 2 and the RMSEA value is between 0.05 and 0.08.

Table 2

*Values discovered as a result of CFA*

| Fit Indexes        | Good Fit                         | Acceptable Fit                        | Observed Values |
|--------------------|----------------------------------|---------------------------------------|-----------------|
| $\chi^2$           | $0 \leq \chi^2 \leq 2\text{df}$  | $2\text{df} < \chi^2 \leq 3\text{df}$ | 313.92          |
| p-value            | $.05 < p \leq 1.00$              | $.01 \leq p \leq .05$                 | 0.041           |
| $\chi^2/\text{df}$ | $0 \leq \chi^2/\text{df} \leq 2$ | $2 < \chi^2 / \text{df} \leq 3$       | 1.154           |
| RMSEA              | $0 \leq \text{RMSEA} \leq .05$   | $.05 < \text{RMSEA} \leq .08$         | 0.061           |
| SRMR               | $0 \leq \text{SRMR} \leq .05$    | $.05 < \text{SRMR} \leq .10$          | 0.11            |

Data diversification was carried out during the qualitative data collection process. Data were obtained from six different types of information sources during the research process, confirming the consistency of the data obtained from different information sources. Furthermore, to ensure the study's reliability, the data were coded by a second researcher, and the codes were cross-checked to investigate the compatibility between the coders. For this purpose, the Miles and Huberman model (1994) was used to find the similarity ratio between different users in the coding made using the researcher's coding schemes. The inter-coder reliability of the codes for activities was 0.92, while the inter-coder reliability of the codes for interview questions was 0.83, according to the Miles and Huberman formula.

## Results

### Changes in Students' Self-Efficacy Beliefs towards Geometry

Students' positive self-efficacy Beliefs and Negative Self-Efficacy Beliefs towards geometry, measured by the first and third factors of the scale, were significantly different before and after the pedagogical practice. Positive self-efficacy beliefs increased after the implementation, whereas negative self-efficacy beliefs decreased. In both analyses, the  $r$  values calculated for effect size were moderate ( $r=.49$ ,  $r=.48$ ), compared with Cohen's cut-off points (1988). After implementation, Belief in the Use of Geometry Knowledge did not show statistically significant differences, which is measured by the second factor. In addition, the Self-Efficacy Beliefs towards Geometry of the students obtained by combining these three factors were also significantly higher after the implementation than before it, as well as the effect size, was high ( $r=.52$ ).

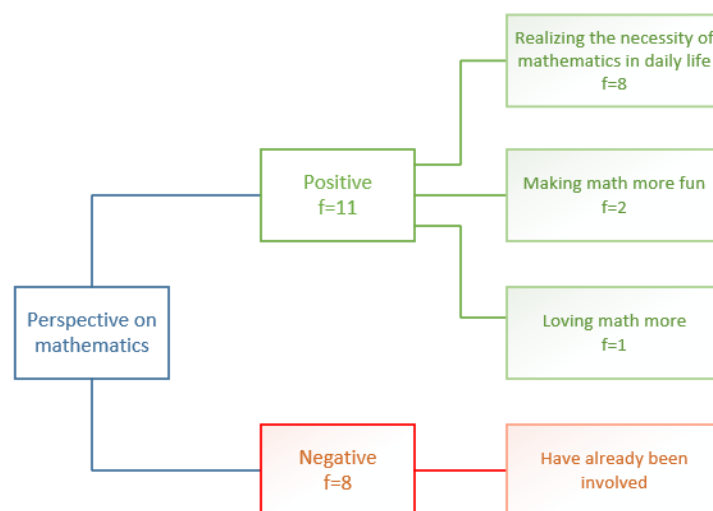
## Opinions of Students Regarding the Learning Process and the Learning Environment

Five sub-headings are used to explain students' views on the learning process and learning environment.

### The Impact of the Learning Experience on Students' Perceptions of Mathematics Course

In both the before and the follow-up questionnaire, students were asked two questions regarding the connection between mathematics and daily life. One of the questions was, "Do geometric shapes catch your attention in your daily life? Could you give an example? ". Before the application, 78% of the 28 students ( $f=22$ ) answered "Yes" to this question, while 22% ( $f=6$ ) answered, "No, it doesn't". The same question was asked again to 19 students who completed the application, and 89% ( $f=17$ ) answered "Yes, I use it", while 11% ( $f=2$ ) answered "No". Following the implementation, three of the six students who answered No before the application changed their answers to positive. According to this study, students are more likely to notice geometric shapes in daily life. Moreover, some students began to question why those geometric objects they noticed were made that way (like a circle, not a square). Additionally, the answers to the questions are more detailed compared to the pre-implementation.

The second question was "Have you used the theoretical knowledge you learned in math class in your everyday life? Could you give an example?" In the questionnaire before the implementation, 85% of students ( $f=24$ ) answered "yes", while 15% ( $f=4$ ) answered "no, I don't use it" and 22 students provided examples. Upon completion of the application, a total of 19 students ( $f=19$ ) answered "Yes, I use it", and they gave examples of how they use it. Moreover, students give more specific examples of how they use the theoretical knowledge acquired in class in daily life. While approximately 60% of the students stated that learning the lesson through activities like this implementation caused a positive change in their perspective on mathematics, the students who claimed that there was no change in their perspective stated that they had always been interested in the Mathematics lesson. As students understand the need for mathematics in daily life, discover that mathematics is more fun, and grow to like mathematics more, they shift their perspective toward mathematics in a positive direction.



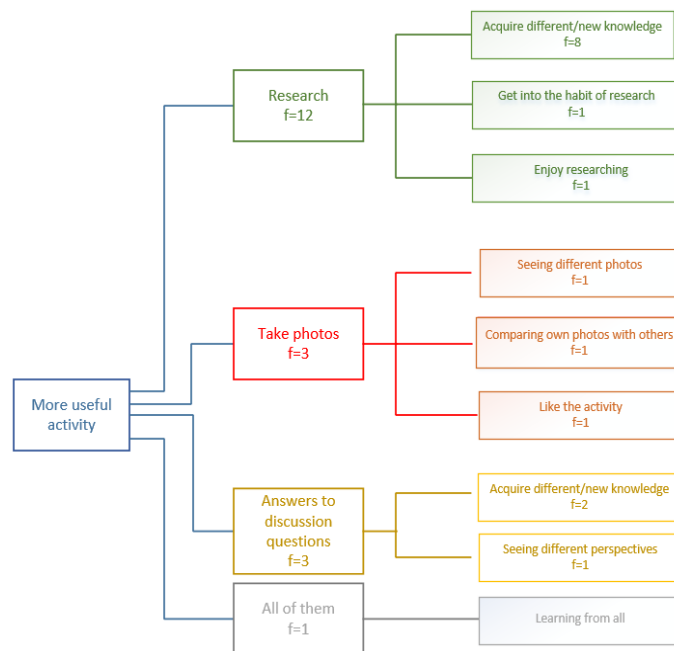
**Figure 3.** Perspective on mathematics

Some of the students' answers to this question are as following: “The application positively changed my perspective on mathematics. I realized our daily lives are filled with mathematics. Even in the most unlikely places, geometric shapes can be found.” (S3). “In real life, I am so intertwined with geometry that I hadn't realized before. Now I pay attention more to what I see.” (S11) “It has changed positively. As a result, I discovered the math lesson might not be seen only in the math lesson itself, and I had a lot of fun uploading the photos. For me, math became enjoyable.” (S7)

Yes. Before this implementation, I considered mathematics to be extremely boring. I used to say math was very hard, but I found I enjoyed mathematics more as I became more proficient in it as a result of these activities. Since I am hyperactive and love to explore, I enjoyed doing research as a part of these activities too much (S14)

### Opinions of Students on the Learning Activities They Performed

The students were asked the question of which of the activities they actively engage in they find more useful and why. The majority of students stated that the "Research" activity was more beneficial than the other activities. The "Research" activity was followed by "Photographing" and "Answers to the discussion questions". According to the students, the "Research" activity was useful because they learned different/new information as they researched, acquired the habit of researching, and enjoyed doing it. Three students said that the "Taking Photograph" activity in the process was more beneficial for them than other activities; they noted that they encountered different photographs, they could compare their photographs with those of their friends, and they enjoyed taking photos. Three students stated that the "Answers to the discussion questions" activity was more helpful for them; by doing so, they gained a variety of new information and gained a better understanding of other perspectives. A student reported that all the activities in the process were beneficial for her since she was able to learn something from each of the activities.

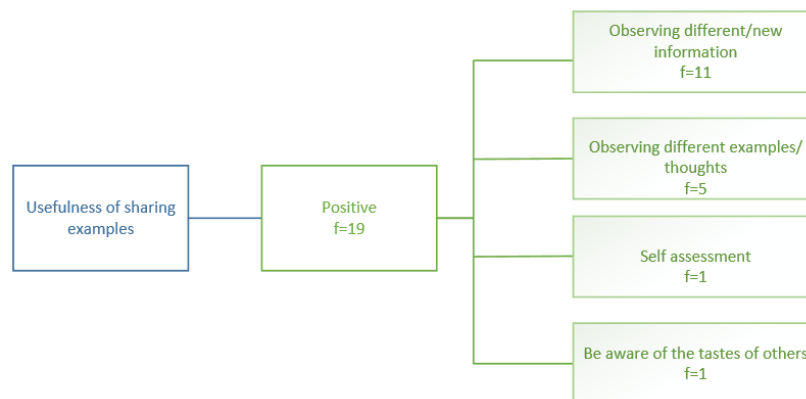


**Figure 4.** Activities found useful by students and their reasons

Some of the students' answers to this question are as following: “Research provides us with new information we didn't know before. As an example, I was pleasantly surprised to see photographs of cells while researching cells. It never occurred to me that they had such beautiful colors and shapes.” (S5) “Photographing. When I photographed it, I was able to compare whether it really resembles that shape or not.” (S4) “It was helpful to see photos of my friends. This is because it is always nice to see other's opinions and actions. The flag photos others posted, for instance, were nice and fun to see.” (S13)

I think the answers to the discussion questions were more helpful. Because I've seen my friends' point of view. As a result of my friends' comments, I have gained valuable insight. There were times when I saw things that they said but I forgot to say or never considered. (S7)

All of the students stated that it was beneficial to share the examples they found with their friends. There are two obvious reasons for this: they gain different/new information from what is shared and they can see different examples/thoughts.



**Figure 5.** The reasons why students find it useful to share the examples they find with each other

Some of the students' answers to this question are as following: “It was helpful. We realized our mistakes after seeing what others shared. It was also useful to see the examples.” (S13)

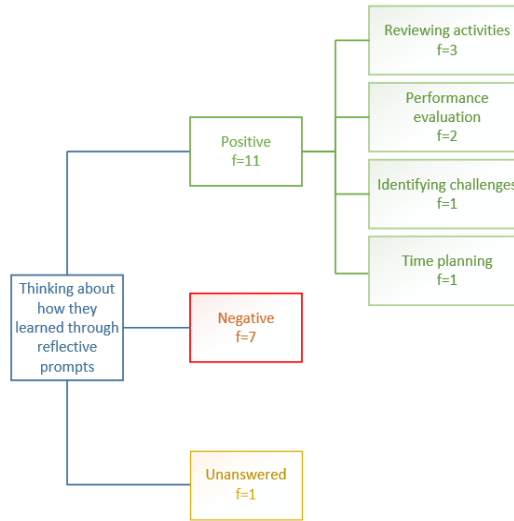
Yes, it was helpful. It might seem at first that we don't understand what we are learning at school, but once we solve the example we see what is going on. Similarly, we've seen a wide range of examples in this implementation which helps us fully comprehend. (S4)

I think it was helpful. The reason for this is that we present our own opinion and our friends can comment when they disagree with it. Their opinions can be useful to us. The students can tell what they like when they like it, so I think it was very helpful. (S7)

### Opinions of Students on the Reflection Process

To obtain students' opinions on the reflection process, two questions were directed to them as part of the pedagogical practice. 60% of the students said that reflection questions directed at themselves helped them reflect on

their learning. Reflection questions made students think about reviewing activities, evaluating performance, identifying challenges, and scheduling as a way of learning.



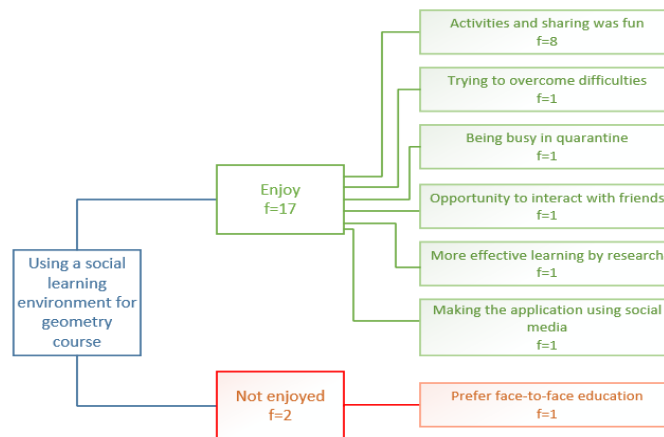
**Figure 6.** Students' ways of learning were influenced by reflective questions

Some of the students' answers to this question are as following: “Yes. I think about all the activities, did I do them right, did I make any mistakes; I review them all before answering that question.” (S3) “Yes, it reminds me that I might have done something wrong or forgotten something.” (S12)

Yes, it did. Although the questions may be the same every week, the activities we do each week differ, so the answers will vary from week to week. To find the answers, we look back at what we did this week and revisit our past experiences and remember them. (S7)

### General Evaluations of Students on the Pedagogical Practice

The majority of the students stated that they liked to learn the geometry course through this pedagogical practice. The most commonly cited reason was that activities and sharing were fun. According to this study, one of the most prominent reasons students enjoyed this application was "being busy in quarantine".



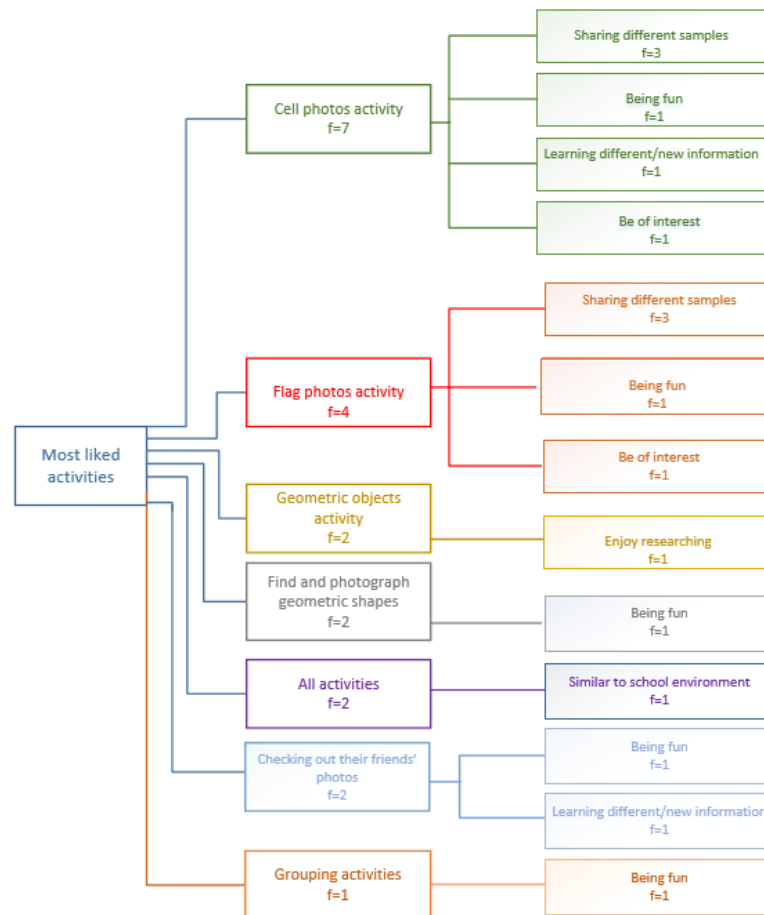
**Figure 7.** Enjoying this pedagogical practice for geometry course and the reasons

Some of the students' answers to this question are as following: “Yes, I liked it. It was good and fun. In addition to learning new things, we also had fun. I enjoyed researching, taking pictures, sharing them with my friends, learning, and having fun at the same time.” (S2) “This way of learning the lesson was really enjoyable for me. It was a lot of fun and I will never forget.” (S6)

Yes. Because most people have their phones with them at all times, they respond immediately to notifications when they receive them. However, whenever we have to write something on a piece of paper or solve a test, we always procrastinate. But when it's like this, we can do it right away. Using a phone can add speed to any lesson since it will be easier to finish if everyone uses a phone. (S2)

I liked it, I thought it was pretty fun. We've been staying at home more because of the pandemic and at least we're busy with these activities. Getting the lesson in this way improved my use of technology. I learned new things I didn't know before. As I did activities, I had fun and felt like I was with my friends. I learned what they do at home and how they spend their time. (S3)

Cell photos and flag photos are students' favorite activities. Additionally, students enjoyed the activity of the geometric object, finding geometric shapes and photographing them, grouping activities, and checking out their friends' photos and all activities. Most students said that they like these activities because it's fun, they share different examples, they learn different/new information and they're interested.

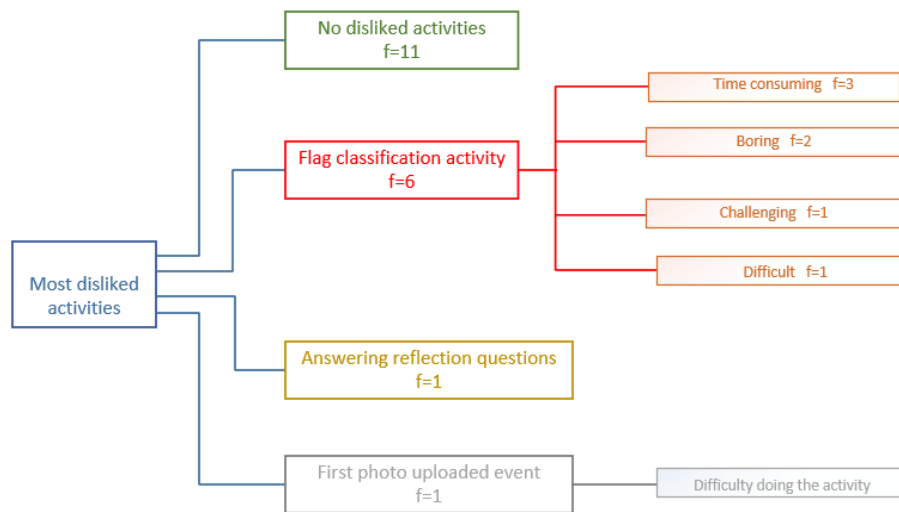


**Figure 8.** Most liked activities and their reasons

Some of the students' answers to this question are as following: “My favorite activity was the flag photos activity. It was nice to research it online and share it on Edmodo.” (S13)

In one example, you wanted us to find flags with geometric shapes among the different countries flags and upload the photos of those who came to us differently. Looking for that photo and showing it to our friends was fun. (S3)

According to 60% of the students, there was no activity they did not like, but 30% named classifying the flags as their least favorite. The students who disliked classifying flags said it took too long, it was boring, it was challenging, and it was difficult.

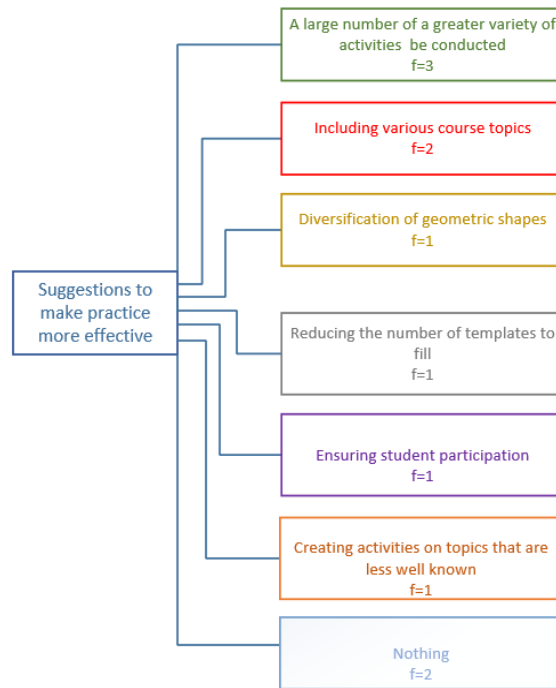


**Figure 9.** Most disliked activities and their reasons

Some of the students' answers to this question are as following: “That flag activity, sorting flags. It was hard, or rather it took a long time. The process of classifying all the flags one by one was a bit tedious. After half of it, it got pretty boring.” (S2)

My least favorite activity was probably the one where we uploaded our first photo. In addition to having trouble finding a photo, I also had trouble with the template. Since it was our first time doing something like this, I didn't know how to do it. Over time, I learned with the help of you, and my brothers. (S7)

To make practice more effective, students suggested that a larger number of and a greater variety of activities be conducted, including various course topics, diversification of geometric shapes, reducing the number of templates to fill, ensuring student participation, and creating activities on topics that are less well known.



**Figure 10.** Suggestions to make practice more effective

Some of the students' answers to this question are as following: “As an example, we photographed a triangle and a rectangle. It would be nice if there was a circle, too.” (S13) “You can share lesser known things or questions. Researching them thoroughly on the Internet and responding accordingly would have been a good idea.” (S17)

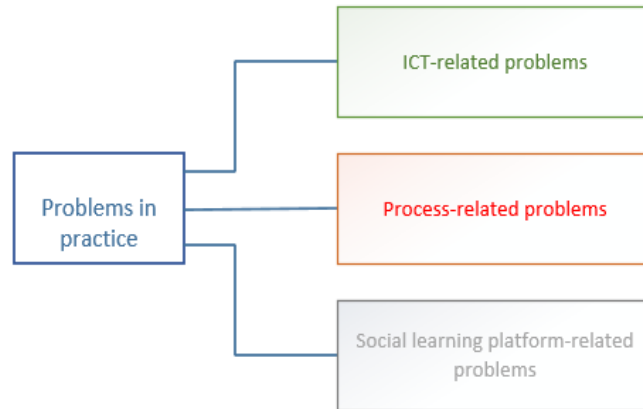
### General Evaluations of Students Regarding the Problems Encountered in the Pedagogical Practice

According to the researchers' observations, the problems experienced in practice are classified under three themes, information and communication technologies-related problems, process-related problems, and social learning platform-related problems. In terms of the use of information and communication technologies, some students, especially those who use mobile applications, have difficulties editing, saving, and reloading the Word templates uploaded by the researcher. Observations show that students lack sufficient digital literacy skills to deal with multiple files simultaneously. In the fifth and sixth grades, students who take the Informatics Technology and Software course may not have the proficiency in using some basic word processors that they are supposed to use within the scope of this practice because the school does not have a computer laboratory, which means that lessons are taught theoretically.

The biggest problem with the process is that it coincides with a period where education takes place remotely due to the Covid-19 epidemic, which makes it more difficult to maintain students' interest and motivate them in comparison to face-to-face learning.

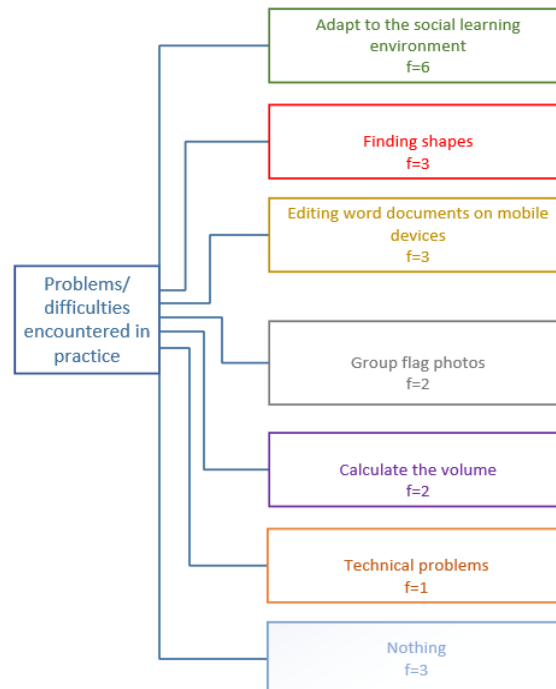
A problem with the social learning platform was that the application version was not fully translated into Turkish, causing students to have difficulty using it. Moreover, students who use mobile applications often stop making

corrections because the application version does not allow editing of the comments after responding to the discussion questions.



**Figure 11.** Problems experienced in practice

On the other hand, students stated the following problems and difficulties; it is hard to adapt to the social learning environment, to find the geometric shapes in the home environment every week, to edit word documents on these devices for those who don't use computers, to group flag photos, to calculate volume, and to solve technical problems.



**Figure 12.** Problems/difficulties faced by students in practice

Some of the students' answers to this question are as following: "I was having trouble filling out Word documents from my phone, so I asked you, and you helped. My efforts in every activity reinforced it better, and the information was settled" (S3) "During orientation week, I had difficulties. After that, I had no problems. In the first activity, I didn't know exactly where to upload it and I tried to upload it in the wrong location." (S4) "It was at first. As a beginner, I had a very difficult time uploading templates, as well as uploading photos. As I learned, it became easier." (S5)

### Discussion, Conclusion & Suggestions

In this study, it is aimed to examine the change in the self-efficacy beliefs of secondary school students towards geometry as a result of the pedagogical practice based on Realistic Mathematics Education (RME) and investigate their views on the learning process and learning environment. For this purpose, both quantitative and qualitative data were used.

Quantitative results show that the Self-Efficacy Beliefs towards Geometry of the students obtained by combining these three factors were significantly higher after the implementation than before it, as well as the effect size, was high. In addition, students' positive self-efficacy beliefs toward geometry were significantly increased and their negative self-efficacy beliefs toward geometry were significantly decreased after the pedagogical practice. As shown by these results, the practice contributes to students' self-efficacy beliefs in geometry. An individual's level of self-efficacy can be defined as the level of confidence they have in their own ability to perform certain actions or achieve certain results (Bandura, 1977). An individual's self-efficacy affects his/her determination to initiate a behavior, overcome difficulties he/she encounters while performing a task, and complete the task successfully (Bandura, 1997). Numerous results in the literature indicate that students' mathematics achievement is positively related to their self-efficacy beliefs about the lesson (Erdoğan, Baloglu & Kesici, 2011; Hackett & Betz, 1989; Kaba, Boğazlıyan & Daymaz, 2016; Manstead & Van-Eekelen, 1998; Özkeleş Çağlayan, 2010; Pajares & Graham, 1999; Üredi & Üredi, 2005). It has been shown in the literature that students' self-efficacy beliefs in geometry increase similarly as a result of applying mathematics to various constructivist learning environments (Kandil, 2016) or through applications that integrate mathematics lessons with everyday life (Cantürk-Günhan & Özen, 2010). These kinds of pedagogical practices are therefore thought to trigger self-efficacy in mathematics classes and lead to success. Similarly, teaching geometry based on realistic mathematics education has been found to have a positive effect on student achievement (Özdemir & Üzel, 2013).

Although the posttest scored higher than the pretest in all three dimensions of the scale, the difference was not statistically significant in the dimension "Using Geometry Knowledge". The items in the dimension "Using Geometry Knowledge" consist of expressions that allow students to apply their theoretical knowledge to practical situations. For example, "I solve mathematical problems using geometric shapes", "If I lose my way in a foreign place, I can use my geometry knowledge to find my way", or "I can create a new geometric shape using geometric shapes". Thus, despite the practice, it appears that the students lack enough self-confidence about the application phase of geometry.

A qualitative study was conducted to examine students' views on the learning process and learning environment within the scope of this practice. In this context, we examined the impact of the learning experience on students' perceptions of mathematics courses, their perceptions of the learning activities they performed, their opinions about the reflection process, their general evaluation of pedagogical practice, and the problems they experienced in practice.

It has been observed that, as a result of the practice, students are more aware of geometric shapes in everyday life and are more likely to use the theoretical knowledge they have learned in mathematics lessons in their day-to-day lives. While around 60% of students said that this practice caused a positive change in their perspective on mathematics, those who said they had no change said that they already liked the math lesson. Likewise, real-life examples associated with math produced positive results in similar studies. [Sharma \(2018\)](#) studied three topics from the mathematics curriculum including real-life activities with the participation of university students. At the end of the 5-week course, 90 percent of the students said real-life activities helped them understand math concepts and also connect classroom math to real life. Meanwhile, [Townsend \(2016\)](#) created three real-life activities related to algebraic functions for 8th-grade students in her study. The researcher concluded that participating in these activities lead to a positive change in students' views about mathematics and an increase in their self-efficacy. Another photo-sharing activity in the literature also produced similar results, in which students from undergraduate biology and chemistry courses were given authentic tasks related to real-life examples to facilitate the transfer of theoretical knowledge they had learned in the school outside the classroom. In their statements, students stated that the activity enabled them to successfully link their formal learning with real-world experiences ([Waycott, Dalgarno, Kennedy & Bishop, 2012](#)). According to these studies in the literature, the integration of real-life practices into the lesson contributes both to gain a perspective and to a more meaningful learning experience.

Within the scope of the pedagogical practice, students actively conducted research, photographed, and answered discussion questions. While the majority of students found the "Research" activity more beneficial than the other activities in this process, this was followed by "Photography" and "Answering discussion questions". The students found the "Research" activity more useful than other activities, since they gained different/new information, developed the habit of researching, and enjoyed researching. The students who stated that "photography" was their favorite activity in the process; believed that encountering different photos and being able to compare their pictures with their friends was beneficial. Moreover, all of the students expressed that sharing the examples with their friends was beneficial. Obtaining new information from the shared examples and seeing different examples/thoughts are the most obvious reasons they think it is beneficial to share the examples they discover. Results from a similar study support the views of the students in this study. This study asked 2nd-year biology students to take photos of insect samples, save them in an insect gallery, and compare their insects with other insects in the exhibit based on their physiological characteristics. According to the students, the practice helped them to better share their knowledge and ideas with other students. Also, students stated that they were able to evaluate their progress by comparing their work with others ([Waycott, Dalgarno, Kennedy & Bishop, 2012](#)). As well, in another study, aimed at bridging undergraduate students' formal chemistry learning with their daily lives by taking sample photos of chemical events from their daily lives and uploading these pictures to Flickr, students found the learning activity enjoyable and

expanded their experience of the subject. The students also claimed that the activity gave them the chance to observe other students' work (Kennedy et al, 2009). As a result, research, photography, and sharing activities are all important resources for students to engage in during their learning processes, as shown in other studies conducted among different age groups and courses. Considering the capabilities of social learning environments in terms of social interaction and sharing of content, it is seen that using them in the classroom will be beneficial in terms of learning from each other's posts and ideas, which will enable students to see different perspectives and expand their perspectives.

Approximately 60% of students said that reflection questions at the end of each week make them think about what they learned. The reflection questions encouraged students to think through their learning activities, evaluate performance, identify challenges, and schedule their time. Learning occurs not only through experiences but also through reflections on those experiences (Kaufman, 2004). The process of reflecting on experiences allows learners to keep track of processes by analyzing and interpreting the situation and their performance. This leads to the development of new strategies and improvements. The majority of students reported that they enjoyed learning geometry in a social learning environment and rated their experiences as "fun".

Cell photos and flags photos classification are two of the most popular activities among students. There are a variety of reasons for liking, including being fun, sharing different examples, learning new information, and being interested. According to 60% of the students, there were no activities they disliked, but 30% disliked classifying the flags. Classifying flags is seen as a time-consuming, boring, challenging, and difficult activity. These are the reasons why students disliked it. To make the application more effective, students suggested that the number of activities should be expanded and diversified, geometric shapes should be more diverse, different lessons should be included in the activities, as well as the number of templates required for geometric shape photos uploaded in some weeks reduced. In practice, students face difficulties adapting to the social learning environment of the application, finding geometric shapes within the scope of their activities every week in the home environment, editing Word documents for people who use mobile devices instead of computers, grouping flag photos, calculating volumes, and technical problems.

### **Limitations and Suggestions for Future Research**

Since the study was conducted completely remotely because of the worldwide Coronavirus epidemic, students were unable to take advantage of the school's technological opportunities, so the use of the online social learning environment was restricted to the home environment's equipment and infrastructure. Moreover, this situation has made it impossible to reach students who lack technological access at home. Meanwhile, students participating in the practice on their mobile devices had the biggest problem downloading the Word templates provided with the activities, editing them, and uploading them back to the system. Those students without home computers are at a disadvantage since the mobile app version of the social learning platform is not fully translated into Turkish. These limitations can be overcome by implementing similar applications as extracurricular applications to support lessons during the times when schools and computer classes are open to students' services. In addition, students may utilize a different mobile application where the problems encountered will not occur.

The study has another limitation in that six students, about one-third of the participants, do not have any social media accounts aside from Edmodo, so this was their first experience using social media. Consequently, the responses given by 6 students to the question about the problems and difficulties they encounter in practice seem to highlight problems related to adapting to the social learning environment. Performing a similar study with students who actively use social media will allow the practice to be evaluated for experienced students.

A notable finding was that there was no statistically significant increase in students' self-efficacy beliefs regarding geometry on the "Using Geometry Knowledge" sub-dimension. Therefore, it is recommended to investigate deeply why this sub-dimension isn't developed enough and to try to determine what types of activities can help students apply and use their geometry knowledge more effectively.

### **Ethic**

Ethical approval for our research, 'Investigating the Impact of Real-World Contexts on Geometry Learning and Student Perceptions,' was obtained from Gazi University's Ethics Subcommittee. This approval was granted during their meeting on March 3, 2020 (Meeting No: 03), and is officially documented under committee number 91610558-302.08.01.

### **Author Contributions**

Yasemin Gök managed the crucial tasks of conducting the literature review, gathering the necessary data, and performing the subsequent analysis.

Sibel Somyürek played a pivotal role in shaping the research design and provided comprehensive supervision for all studies conducted within this project.

### **Conflict of Interest**

Authors declares that they have no conflict of interest.

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