ORIGINAL ARTICLE

Engineering Design-Based STEM Activity for Middle Schools: How Can I Slide Faster?

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***Abstract**: In the current study, an engineering design-based STEM activity was designed and implemented for 5th graders. The current activity is expected to provide guidance and perspective to teachers (practitioners) in designing and implementing an activity based on design-based learning, STEM activity, and engineering design process (EDP). At the same time, during the implementation of the activity, teachers and students experienced a STEM activity based on the EDP. In the fall semester of the 2022-2023 academic year, this STEM activity based on the engineering design process was planned for Friction force and water resistance in the 5th-grade middle school science course. Then, the activity was implemented in a class of 21 students. The activity was implemented in three class hours. This activity, titled "Let's Design a Water Slide Boat," aimed at designing a water slide boat that would be least affected by water resistance and friction force to improve students' engineering and design skills. This activity was based on NGSS and the objectives and outcomes set in the 5th-grade science curriculum of the Turkish Ministry of National Education.*

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Introduction

THE PRIMARY objective of education should be to raise people with the so-called 21st-century skills, which are becoming more and more crucial day by day. These skills include innovation, design thinking, entrepreneurship, questioning, teamwork, analytical skills, and science and technology literacy (Aranda et al., 2020). Design-based learning (DBL) is essential to achieving this objective. DBL can be described as a teaching strategy incorporating content knowledge into the creative production process so that students design artifacts to address real-world issues with Papert's theory of constructionism (Doppelt et al., 2008). Through DBL, it may be possible to teach science to students, provide motivation, and guide students toward engineering careers (Chandrasekaran et al., 2013).

The engineering design process is used in DBL, as is evident from this (Dopplet & Barak, 2021). Engineering Design Process (EDP) is defined as a set of processes that includes the steps of selecting the best way to solve a problem, conducting research, and creating products (National Research Council [NRC], 2009). In its most basic sense, the engineering design process is the set of ways engineers solve problems. Engineering design is also characterized as an essential teaching-learning tool for developing skills such as open-ended problem-solving, creative thinking, solution generation, decision-making, and evaluation of alternative solutions (Wang et al., 2013). As can be inferred, some steps in the engineering design process are also found in science and technology. In addition, the fields of science and engineering mutually feed each other (Next Generation Science Standards [NGSS], 2013; NRC, 2012). At this point, for quality education, it is recommended that the scientific research inquiry process and the engineering/technology design process should operate together in the learning process (NRC, 2012). The focus of STEM education, which is based on integrating science, technology, engineering, and mathematics (STEM) disciplines, is also to enable students to integrate scientific knowledge and practices using real-life engineering problem-solving and creative design processes (Lou et al., 2014). From this perspective, combining the content knowledge of science and engineering disciplines with science and engineering practices is essential, thereby increasing students' knowledge and skill levels. To achieve this, students are expected to solve engineering problems in a real-life context within the framework of a specific theme they are confronted with (NRC, 2012). There are different variations of the EDP. For this reason, it is more important to focus on the standard components in the variations, such as defining the problem, setting the criteria for solving the problem, realizing prototype designs, and finding the best solution (NGSS, 2013). In EDP, a cyclical process, the solution to the problem is either a model (design-prototype) or a modeling (Hynes et al., 2011; NRC, 2012).

EDP education contributes to students' academic achievement (Mehalik et al., 2008), transfer of knowledge to real life (Thomas, 2014), and development of 21st-century skills (Bybee, 2010; Stehle & Peters Burton, 2019). It positively affects learners' interest, attitude, and motivation toward STEM disciplines and develops their career awareness (Baran et al., 2015; Christensen & Knezek, 2017). As a result, individuals who have acquired design skills are expected to be able to solve the problems they face in daily life, think innovatively and creatively, be self-confident, entrepreneurial, and technologically literate, and pursue careers in scientific fields (Bybee, 2010). Despite all this importance, traditional classroom environments must be improved regarding design activities. Learners need to be provided with design skills and, thus, the ability to solve design problems they may encounter in real life (Moreno et al., 2016).

On the other hand, science instruction is a complex process, and students typically need to improve in science (Fokides & Papoutsi, 2020). Considering this situation, the EDP-based science education process comes to the forefront to improve the quality of science education, which is closely related to science, technology, and society and whose nature overlaps with the process of engineering and scientific research, and to build a society of science learners with developed 21st-century skills. Indeed, NRC (2012) emphasizes the components of science education, such as developing science literacy, problem-solving, and engineering skills, and conducting research with scientific ethics.

When the literature is examined, it is clear that there are numerous studies on designing and adapting engineering design-based activities on friction force for teachers (Hacıoğlu, 2020), designing activities for children in their early years (Ata Aktürk, 2023; Tanık Önal & Saylan Kırmızıgül, 2021) and high school students (Baptista & Martins, 2023). Applied studies in the field of STEM in the literature are generally conducted with the participation of pre-service science teachers (Buber & Unal Coban, 2020) and middle school students (Wieselmann et al., 2020).

In our study, a STEM activity about water resistance and friction force was designed for 5th graders based on the EDP. The selection of 5th graders in our study is essential. Studies examine the effect of STEM-based activities integrated with the 5th-grade science course content on students' problem-solving skills and academic achievement. For example, the article by İnce et al. (2018) investigated how integrating STEM-based activities with science course content affected students' problem-solving skills and academic achievement related to the earth's crust. The results showed a significant increase in students' problem-solving skills and academic achievement in STEM-based activities. The study conducted by Eker (2020) examined the effect of STEM activities prepared based on the 'Measurement of Force and Friction' and 'Matter and Change' units in science courses on students' motivation and entrepreneurship. The results showed that the teaching method supported by STEM activities increased students' motivation but did not provide a statistically significant increase in entrepreneurship skills. Keçeci et al. (2017) examined students' attitudes and emotions toward coding learning through STEM education practices consisting of guided inquiry, inquiry-based science activities, coding education, and educational game-supported coding learning. The results showed a significant increase in attitude towards coding learning supported by educational computer games and that students found the science activities enjoyable. Some even preferred to experience them again with their families. In conclusion, designing an EDP-based STEM activity about water resistance and friction force for 5th grade students is of great importance for students to gain experience in the STEM field and develop their problem-solving skills. Such activities can increase students' motivation and academic achievement by providing them with more in-depth knowledge in the fields of science, technology, engineering, and mathematics. Kahveci (2020) analyzed the science textbooks in Türkiye in terms of STEM criteria and found that the activities in the 5th-grade textbook partially met the necessary criteria, and most of the activities for science, engineering, and entrepreneurship practices in the textbooks of other grades did not meet the criteria. This is important because students have experienced STEM activities based on EDP before.

According to studies conducted in Türkiye, STEM education textbooks are inadequate, and even though teachers want to implement STEM activities, they encounter challenges (in terms of the practitioner's competencies, the availability of materials, and cooperation), which makes them hesitant (Özbilen, 2018). Again, according to the literature, teachers have difficulty presenting problems that will enable students to make interdisciplinary connections and carry out the research process (Diana, 2021). With this in mind, it can be said that there is a need for STEM activities to spread throughout society, particularly in Türkiye, and for practitioners to develop their skills and knowledge.

This study aims to design and implement an engineering design-based STEM activity for fifth-grade students. This activity is expected to guide teachers (practitioners) in developing and implementing an activity based on design-based learning, STEM activity, and EDP (Engineering Design Process). At the same time, during the implementation of the activity, teachers and students will experience a STEM activity based on EDP. For these purposes, the research questions are as follows:

- How can an engineering design-based STEM activity be designed and implemented for fifth-grade students?

- How can this activity provide guidance and perspective to teachers in designing and implementing an activity based on design-based learning, STEM activity, and EDP?
- Can teachers and students experience a STEM activity based on EDP during its implementation?

Method

In the fall semester of the 2022-2023 academic year, this STEM activity based on the engineering design process was planned for Friction force and water resistance in the 5th-grade middle school science course. Then, the activity was implemented in a class of 21 students (11 girls and 10 boys). The activity was implemented in three class hours (40+40+40+40 minutes).

This activity, titled "Let's Design a Water Slide Boat," aimed to design a water slide boat that would be least affected by water resistance and friction force to improve students' engineering and design skills. This activity was based on NGSS (2017) and the objectives and outcomes set in the 5th-grade science curriculum of the Turkish Ministry of National Education (MoNE, 2018) (**Appendix 1**). At the end of the activity, students are expected to achieve the following STEM acquisitions.

STEM Acquisitions

- Gives real-world illustrations of friction force.
- Generates new ideas to increase or decrease friction in daily life.
- Defines a daily life problem.
- Creates ideas for solving the problem.
- Draws various designs for the solution of the problem.
- Identifies the limitations of their designs.
- Creates the design (prototype).
- Tests the design.
- Improves the design.

The activity was planned based on NASA's (2011) engineering design cycle. According to this cycle, the steps of asking questions, imagining, planning, creating, testing, and improving follow each other cyclically. Before the activity, the students were informed about this cyclical process.

Ethics Rules Taken into Account in the Study

In this activity design and implementation study, the whole process was explained in detail to ensure the transferability of the research. In addition, after the activity was designed, two field experts were consulted to evaluate the activity. These evaluations focused on qualities such as the appropriateness of the activity for the grade level, whether it meets the outcomes, its suitability for the duration, the appropriateness of the activity for the execution of EDP, the suitability of the problem situation for STEM education, and finally the examination of the boundaries of the design task to be carried out to solve the problem. Expert opinions were that the activity design had no implementation deficiencies. Then, the implementation started. A volunteer teacher implemented the activity. Necessary precautions were taken to prevent the teacher and students from being recognized in the photographs presented in the study.

Activity: Design a Water Slide Boat

Skills Based on the Activity

Scientific Process Skills

Measuring, recording data, hypothesizing, using data and modeling, changing and controlling variables, and experimenting.

21st Century Skills

Analytical thinking, decision making, creative thinking, communication, teamwork, entrepreneurship.

Engineering and Design Skills

Innovative thinking, product creation, and approaching the problem from a different perspective.

Equipment/Material (Table 1)

The Connections of the Activity to NGSS

The design of the activity also took the Next Generation Science Standards (NGSS) into consideration. **Table 2** lists the NGSS that are relevant to the activity. The activity is closely related to three K-12 Science Education Framework elements, as stated in **Table 2**.

Implementation of the Activity

Table 1. Equipment and Material Prices.

Needle (1 for 1 TL)	Eva (1 for 2 TL)
Scissors (5 TL each)	Yarn (1 meter 1 TL)
Paper (1 TL for five)	Cotton (8 TL for 50 g)
Waste materials (Free of charge - It makes students care about recycling)	Chenille (1 TL each)
Ruler (5 TL each)	Eva (1 TL each)
Pencil (1TL each)	Wooden ice cream sticks (50 kr. each)
Glue (5 TL for a tube)	Tape (5 TL for a roll)
Silicone gun (50 TL for one) (Silicone gun will be used under teacher control)	Thin silicone (2 TL for 1)

Table 2. The Connections of the Activity to NGSS (NGSS, 2017).

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
• Planning and Carrying Out Investigations • Analyzing and Interpreting Data • Constructing Explanations and Designing Solutions • Obtaining, Evaluating, and Communicating Information	PS2.A: Forces and Motion • Pushes and pulls can have different strengths and directions. • Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it. PS2.B: Types of Interactions • When objects touch or collide, they push on one another and can change motion. PS3.C: Relationship Between Energy and Forces • A bigger push or pull makes things speed up or slow down more quickly. ETS1.A: Defining Engineering Problems • A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions.	Cause and Effect • Simple tests can be designed to gather evidence to support or refute student ideas about causes.

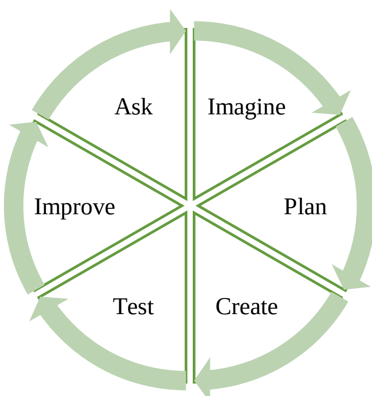

Figure 1. The Engineering Design Process by NASA (2011).

The activity was planned based on NASA's (2011) engineering design cycle. According to this cycle, the steps of asking questions, imagining, planning, creating, testing, and improving follow each other cyclically (**Figure 1**).

Ask a Question: (15min)

This activity phase aims to develop students' ability to find solutions to the problems they encounter in daily life. The problems presented to the students were designed to reveal their prior knowledge and draw their attention to the topic. Then, the questions posed by the teacher to the students were intended to stimulate their thinking abilities and problem-solving skills. The students' answers show their ability to analyze the problem situation, generate possible solutions, and share similar experiences. This activity aims to develop students' critical thinking and creative solution-finding skills**.**

First, the daily life problem shown in **Figure 2**, which was prepared by the teacher to reveal the students' prior knowledge and draw their attention to the topic, was presented.

After the students read the problem situation, the teacher asked the following questions to the students.

- What do you suppose Mert's inability to move quickly down the slide could be?
- If you were in Mert's shoes, what would you do to make it easier for him to slide?
- Did anyone ever have a similar problem while sliding down the slide before? (If so, how did you solve the problem?)

The answers given by the students to the questions are summarized as follows:

The students stated that the reasons for Mert's inability to slide fast down the slide could be that the slide was rough, the child's shorts, the friction were too much, and the child's body prevented him from sliding.

Students responded to the question *"If you were Mert, what would you do to slide more easily?"* with responses like "I would wear smoother shorts." "I would slide on a bagel." "I would slide with a plastic bag." and "I would foam my body."

In addition, in response to the question *"Has anyone ever experienced a similar problem while sliding down a water slide before? (If so, how did you solve the problem?)"*, students answered, "We have never been on a water slide before, so we have not experienced such a problem.", "No, we have not experienced such an incident.", "We have not been on a water slide before, so we have not experienced such an incident.'' and ''We have not been on a water slide before, but I was wearing shorts while sliding in the park and my legs were sweaty and stuck to the slide and I had difficulty sliding. So, I slid by putting cardboard under me."

DESIGN TASK

How Can I Slide Faster?

Mert has been dreaming of a nice vacation all year and finally summer vacation has arrived. Mert likes to spend most of his time at the water slides in the hotel pool and he is very excited to slide down the water slide. At his first slide, Mert doesn't enjoy it very much because he slides very slowly, and it hurts a little.

Figure 2. Design Task.

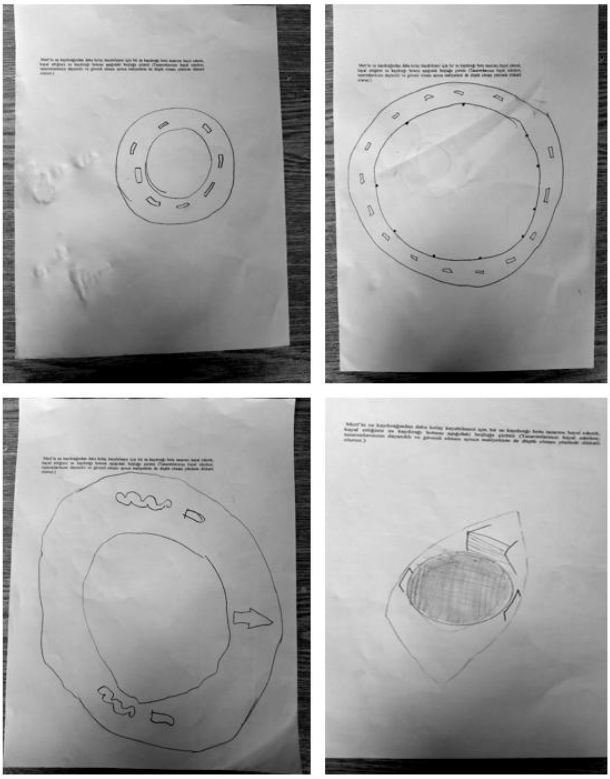

Figure 3. Design Sketches.

Imagine: (15min)

At this stage, students were divided into groups of four or five. Each group was asked to imagine a water slide boat design so that Mert could slide down the slide more easily. While the groups were imagining their designs, they were asked to be careful that their designs should be durable, safe, and cost-effective.

Plan: (20min)

The teams created design drawings by sketching out their envisioned creations on paper (**Figure 3**). They tried to keep the cost of the materials they would use in their designs low. This stage allows students to concretize their design and turn it into a practical plan.

Create: (40min)

The groups created their designs in line with the drawing they planned and designed (**Figure 4**). They wrote down the costs of their designs on a piece of paper (**Figure 5**). This activity phase aims to create designs in groups using the drawings designed by the participants and determine the costs of these designs. In the next step of the design process, the groups will do their best to turn their planned drawings into reality. This stage in the design process enables participants to fulfill a specific task by utilizing their creativity and problem-solving abilities. Also, determining costs helps participants develop their budget management skills and use of resources effectively. This stage represents a practical and hands-on dimension of the design process, enabling participants to transform their conceptual ideas into concrete products while developing their economic thinking skills.

Test: (15min)

At this stage, the designs made by the groups were tested on the slide prepared by the teacher (**Figure 6**). The groups examined their designs for the easiest and fastest way to slide. This activity phase aims to test how effective the designs prepared by the groups are in practice. The groups test their designs on the slide they have prepared. This testing process provides an opportunity to see how the designs work in real-world conditions. Groups evaluate the performance of their designs as they try to determine that their design is the easiest and fastest way down the slide. This stage allows students to experience the practical application of the design process and provides an opportunity to evaluate how well their designs function in real life. In this way, students can develop and improve their designs and, at the same time, develop their engineering and problem-solving skills. This stage allows students to test and evaluate their designs in a real-world context, allowing them to apply the scientific method and engineering principles.

Improve: (15min)

Slow and difficult sliding designs were identified, and the groups finalized the designs by eliminating the faulty aspects.

Figure 4. Examples of Design Studies.

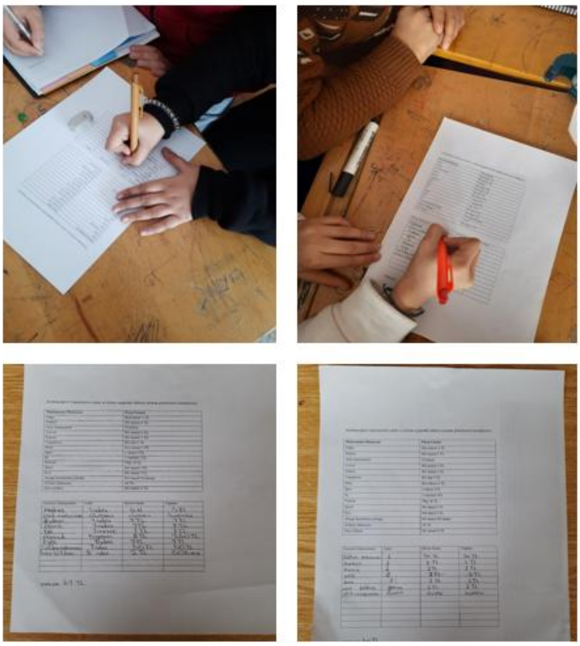

Figure 5. Design Costs.

Figure 6. Testing of the Designs.

Table 3. Design Evaluation Rubric.

Criteria	Points		
Cost of Design	Less than 60 TL 30 points	Between 60-70 TL 20 points	More than 70 TL 10 points
Time to finish the course	Less than 3 seconds 30 points	Between 3-5 seconds 20 points	More than 5 seconds 10 points
Safety	The doll is not hit and does not fall off the boat. 30 points	The doll was hit left and right but the boat did not tip over. 20 points	The boat overturned and the doll was thrown. 10 points
Resilience	It is not affected by liquid in any way. 30 points	The shape is changed by the liquid, but it still functions. 20 points	The shape is completely distorted by the liquid. 10 points

Table 4. Evaluation Rubric for Group Work.

Stages	Performance Level 1	Performance Level 2	Performance Level 3	Performance Level 4
Planning of the Design				
Teamwork	No task distribution was made before starting the design. At the same time, no definition of the needs of the design was made by the group members.	Before starting the design, all tasks were allocated without considering the wishes and skills of the people involved. At the same time, no definition of the needs of the design was made by these people.	Before starting the design, all tasks were allocated without considering the wishes and skills of the people involved. But the needs of the design were defined by these people.	Before starting the design, all tasks were allocated according to the wishes and skills of the people involved. The needs of the design were also defined by these people.
Originality of Design	No discussion was held as a group about how the design should be and no decision was taken about the design.	The group discussed how the design should be, but an original design was not decided on until the end of the process. At the same time, this design was not adopted until the end of the process.	The group discussed how the design should be, but did not decide on an original design until the end of the process. This design was adopted until the end of the process.	The group discussed how the design should be and an original design was adopted.
Drawing Related to Design	No drawing was realized that was suitable for the activity and whose draft could be transformed into a design.	A drawing was made that was not suitable for the event, but the sketch could be turned into a design.	A drawing was made that was in line with the purpose of the event but whose outline could not be turned into a design.	A drawing was made in accordance with the purpose of the event, the outline of which could be transformed into a design.
Making the Design				
Using Materials and Time Effectively	Water-resistant materials were not used for the design and the design could not be completed within the specified time.	Water-resistant materials were used for the design, but the design could not be completed within the specified time.	Water-resistant materials were not used for the design, but it was completed within the specified timeframe.	Water-resistant materials were used for the design and the design was completed within the specified time.
Effective management of the design process	The design was not maintained and managed within the control of the group as a whole or any of its members.	Not all group members were involved in the design and the design was controlled and managed only by one of the group members.	The design was led by only one individual, although it was maintained within the control of all group members.	The design was sustained and managed within the control of all group members.
Cooperation Ability Among Stakeholders	During the design process, there was not a good collaboration between all group members and consequently the workload could not be organized in a controlled manner.	During the design process, it is often the case that all group members failed to cooperate and workload is undertaken by some individuals in the group.	During the design process there was cooperation among all group members intermittently and during these cooperation intervals individuals in the group shared workload equally.	During the design process, there was always cooperation among all group members and the whole group individuals shared workload equally.
Testing the Design and	The design was not tested for its intended purpose at	The intended design was not pursued, and although the	The intended design was not abandoned, and	The intended design was not abandoned, and

Improvement	any point in the process and ideas and solutions for its improvement were not developed.	design was tested intermittently for its intended purpose, no new ideas and solutions were developed.	although it was constantly tested for its intended purpose, no new ideas or solutions were developed.	the design was continuously tested for its intended purpose and new ideas and solutions were developed.
Taking Security Measures	No safety precautions were taken for the storage and use of the materials and no responsible person was identified.	No safety precautions were taken regarding the use of materials. Only one of the group members is identified as the responsible person for the storage of materials.	All safety precautions were taken regarding the storage and use of the materials. However, only one member of the group was designated as responsible for this.	All safety precautions were taken regarding the storage and use of the materials. And all the group members were designated as responsible for this.
Evaluation of the Design				
Creating a Checklist and Using it for Evaluation Purposes	No checklist was created, and the design was not reviewed in any way.	No checklist was created, but the design was reviewed generally.	A checklist has been created but in no way was the design reviewed according to this list but in general.	A checklist was created with the participation of all group members and the design was reviewed according to the entire list.
Being realistic in terms of form and aesthetics	No emphasis was placed on form and aesthetics. Therefore, the design did not reflect reality.	The form of the design was determined. But since it is not based on aesthetics, the reality of the design was not reflective.	The design was all about form and aesthetics, but the design did not reflect reality.	The design was all about form and aesthetics, and the design did reflect reality almost completely.

What did you learn at this event?

What was your favorite part of this event?

Was there a section of this event that you didn't like?

What would you like to be changed in this event?

Figure 7. Reflecting Text.

Evaluation of the Activity

Throughout the activity, the work done by the groups was monitored by the teacher. The designs of the groups were analyzed through the Design Evaluation Rubric given in **Table 3**. While preparing this rubric, the rubric developed by Hacıoğlu et al. (2016) was utilized. The studies of the groups were analyzed through the Group Work Evaluation Rubric given in **Table 4**. While creating this rubric, the rubric developed by Aydın & Karaçam (2015) for evaluating technological designs for groups were utilized. Opinions about the activity were obtained from all students through reflection essays. These opinions are shown in **Figure 7**.

Discussion

"Let's Design a Water Slide Boat" is an activity design and implementation study demonstrating how to incorporate a STEM activity based on the engineering design process into science education. In this study, which deals with the 5th-grade science course Friction Force and Water Resistance, NASA's (2011) engineering design cycle has been taken as a basis. Therefore, in the activity, the steps of asking questions, imagining, planning, creating, testing, and improving follow each other cyclically. Using this cycle ensures that the activity topic designed in the study is associated with daily life. Because it was a STEM activity based on the EDP, the learners could work as engineers and scientists. For a quality science education, it is recommended that scientific research inquiry and engineering/technology design processes should be operated together in the learning process (NRC, 2012). In this way, both scientific research and engineering skills are developed. At the same time, the students understand the differences between science and engineering.

This study, a STEM activity, focused on essential achievements such as associating the science subject with daily life, creating ideas for solving the problem, designing, creating prototypes for the designs, testing, and evaluating the design. Based on design-based learning, this process enables individuals to produce original and creative solutions by approaching problems in a solution-oriented manner. It is reported in the literature that this design process increases students' motivation and encourages them to work collaboratively (Kroper et al., 2011). In support of this, it is stated that it is essential for individuals to have basic theoretical knowledge about the disciplines of Physics, Chemistry, Biology, and Mathematics (basic sciences) and the ability to create new products by combining this theoretical knowledge with knowledge in the fields of technology and engineering. STEM education is a crucial method (Pirrie, 2019). In STEM education, which focuses on production activities, individuals are expected to explore nature and the world innovatively, solve problems while exploring, and produce while solving problems (Affifi, 2019).

When successfully implemented and given the necessary importance to its pedagogical dimension, with this activity, it is possible to provide students with scientific process skills, 21st-century skills, and engineering skills or to develop their existing potential.

The literature supports this by reporting that children participating in STEM education develop scientific process skills (Strong, 2013). Engineering skills, especially innovative thinking, product creation, and the ability to approach problems from different perspectives come to the fore. The 21st-century skills supported in this activity are analytical thinking, decision-making, creative thinking, communication, teamwork, and entrepreneurship skills. The ultimate goal of these applications, which are a variation of design-based learning, is to increase learners' motivation and develop their higher-order thinking skills (Dopplet & Barak, 2021). In today's business world, individual skills such as problem-solving, analytical and creative thinking, and collaborative working are emphasized (World Economic Forum, 2017).

In this study, the fact that the activity was designed and implemented for 5th graders can be considered as a separate value because the literature emphasizes that STEM education should start at the youngest possible age (Chesloff, 2013). In addition, implementing such an activity in the classroom makes students active and ensures participation in the lesson. Similarly, it is stated that design-based STEM education enables children to participate in the process actively (Carroll et al., 2010).

As a result of this activity, the students learned the subject of water resistance and friction force in terms of content, and the knowledge they gained was permanent. This is supported by previous studies reporting that teaching this subject with STEM activities increases students' academic achievement (Changtong et al., 2020; Simeon et al., 2022). It is stated that STEM activities provide lifelong learning and also positively affect the skills of establishing relationships and problem-solving abilities (Wang, 2012). A Meta-Synthesis of studies on STEM education found that STEM education positively affected academic achievement in STEM disciplines and attitude toward school (Yıldırım, 2016). The same study also noted evidence that STEM education strengthens students' problem-solving and creativity.

In the engineering design phase of the activity, the development of learners' psychomotor skills was supported along with their design and creativity skills. In line with this idea, it is stated that using simple tools and materials such as scissors, glue, stickers, and cardboard during STEM activities will improve the skills of their students (Fortunati et al., 2014). Chang & Chen's (2022) research also states that robotics-based STEM activities significantly positively affect psychomotor performance.

This activity improved students' social skills. To substantiate this, the literature claims that STEM education programs help kids develop their social skills (Allen et al., 2019; Strawhacker & Bers, 2018). Collaborative work and communication skills come to the forefront in such activities (Cheng et al., 2013). It is also known that STEM activities provide opportunities for peer learning (Carroll et al., 2010).

This entrepreneurship-oriented STEM activity study aims to improve students' entrepreneurship skills. European Commission reports emphasize the importance and necessity of students' entrepreneurial skills (Council of the European Union, 2011). This situation is also reflected in the curriculum of science courses in Türkiye. In the curriculum, last updated in 2018, three basic skill steps were identified: life skills, scientific process skills, and engineering design skills. Life skills include entrepreneurship, communication, collaborative work, creative and analytical thinking, and decision-making skills. In order to help students acquire these skills, the program includes practices with the theme of "Science, engineering, and entrepreneurship." As a result, students are expected to integrate the scientific content knowledge in the Science course with engineering and entrepreneurship skills and create a product (MoNE, 2018). In this context, this activity, designed and implemented in our study, is an innovative activity to realize these goals of the Science course. In addition, this STEM activity contributes to students' cognitive, affective, and psychomotor skills.

This study, a STEM activity based on the engineering design process, may be used as a model for teaching various science subjects. Implementing STEM activities based on EDP at all educational levels is advised in light of the aforementioned potential outcomes.

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Engineering Design-Based STEM Activity for Middle Schools: How Can I Slide Faster?

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Appendix 1.

WORKSHEET

NAME AND SURNAME,
GROUP MEMBERS

DESIGN TASK

How Can I Slide Faster?

Mert has been dreaming of a nice vacation all year and finally, summer vacation has arrived. Mert likes to spend most of his time at the water slides in the hotel pool and he is very excited to slide down the water slide. At his first slide, Mert doesn't enjoy it very much because he slides very slowly, and it hurts a little.

What do you suppose Mert's inability to move quickly down the slide could be?

If you were in Mert's shoes, what would you do to make it easier for him to slide?

Did anyone ever have a similar problem while sliding down the slide before? (If so, how did you solve the problem?)

Imagine a water slide boat design so that Mert can slide down the water slide more easily and draw the water slide boat you imagine in the space below (While imagining your designs; be careful that your designs are durable and safe and that their cost is low).

Calculate your expenses by writing the amount and price of the materials you will use in the table below.

Equipment/Material	**Price List**
Paper	1 TL for five
Scissors	5 TL each
Waste materials	Free of charge
Ruler	5 TL each
Pencil	1 TL for each
Glue	5 TL for a tube
Tape	5 TL for a roll
Needle	1 for 1 TL
Yarn	1 meter 1 TL
Cotton	8 TL for 50 g
Chenille	1TL each
Eva	1TL each
Wooden ice cream sticks	50 kr. each
Silicone gun	50 TL for one
Thin silicone	2 TL for 1

Materials Required	Pieces	Unit Price	Total

GRAND TOTAL:

Now make the boat which you have drawn.

Together with your group of friends, finish your water slide boat.

Imagine that you decide to sell your water slide boat that you have designed.

- What name will you use to sell your water slide boat?
- To whom will you sell your water slide boat?
- What would be the slogan of your advertisement to sell your water slide boat?
- What distinguishes your water slide boat from others?
- Why should people buy the water slide boat you have designed?