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Research Article

A STEM Activity Focused on Chemistry: Smart Food Packaging

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Abstract

The aim of this study is to introduce a STEM activity in accordance with the problem-based teaching method focused on chemistry course prepared to develop 10th grade students' entrepreneurship and scientific process skills. The activity consists of seven stages. In the first stage, a problem that students may encounter in daily life was presented and they were asked to produce a solution to this problem. The problem is related to smart packaging, which is widely used abroad. In the STEM activity, which was initiated with a story, students were asked to design a smart packaging that is harmless to human health with the cheap and easily accessible materials given to them, to make a prototype and to carry out the promotion and marketing of the product they created. The activity was applied to 25 high school students. Students' opinions about the activity were collected through the activity evaluation form. The students who participated in the activity described the activity as interesting.

Keywords: STEM activity, Problem based learning, Entrepreneurship, Scientific process skills

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Kimya Dersi Odaklı Bir STEM Etkinliği: Akıllı Gıda Ambalajı

Özet

Bu araştırmanın amacı 10. sınıf öğrencilerinin girişimcilik ve bilimsel süreç becerilerini geliştirmek amacıyla hazırlanan kimya dersi odaklı probleme dayalı öğretim yöntemine uygun bir STEM etkinliğini tanıtmaktır. Etkinlik yedi aşamadan oluşmaktadır. İlk aşamada öğrencilerin günlük yaşamda kaşılaşabilecekleri bir problem sunulmuş ve onlardan bu probleme çözüm üretmeleri istenmiştir. Problem, yurt dışında yaygın olarak kullanılan akıllı ambalajlarla ilgilidir. Bir hikâye ile başlatılan STEM etkinliğinde öğrencilerden kendilerine verilen ucuz ve kolay ulaşılabilir malzemelerle insan sağlığına zararsız bir akıllı ambalaj tasarlamaları, prototipini yapmaları ve oluşturdukları ürünün tanıtım ve pazarlama çalışmasını yürütmeleri istenmiştir. Etkinlik 25 lise öğrencisine uygulanmıştır. Öğrencilerin etkinliğe ilişkin görüşleri etkinlik değerlendirme formu aracılığıyla toplanmıştır. Etkinliğe katılan öğrenciler etkinliği ilgi çekici olarak nitelendirmiştir.

Anahtar Kelimeler: STEM etkinliği, Probleme dayalı öğrenme, Girişimcilik, Bilimsel süreç becerileri

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1. Introduction

It is important for countries aiming for economic development to invest in human capital. In the twentieth century, which is also called the "Age of Human Capital," the level of education has become the most important indicator of the productivity of individuals and the level of development of nations. The increase in the level of education of individuals increases not only their own productivity but also the productivity of others with whom they interact; thus, as the average level of education increases, the level of productivity in society also increases (Card, 2001). Many studies in economics have emphasized that education generates economic returns (Öztürk, 2008). Education is like a lever: It enables countries to catch up with or lead the era.

During the transition from the Neolithic age to the information age, many transformations have taken place in education due to the changing needs of society. This transformation process is analyzed in four periods: Education 1.0, Education 2.0, Education 3.0 and Education 4.0. Education 1.0 is the era in which the people needed by the economy based on agricultural production were trained, and education in this era was based on teacher-centered understandings in which knowledge and experience were transferred from master to apprentice. Education 2.0, which started with the Industrial Revolution, aims to train individuals for the industrial sector. With this understanding of education, individuals who work in harmony with their colleagues in the production line were trained. Education 3.0 is a period in which students are in the position of producing information, not just receiving it, and schools aim to raise individuals with diplomas in accordance with social expectations. Education 4.0 aims to raise individuals who can adapt to changes such as rapid transformation, artificial intelligence, robotics, and automation and who can cooperate with robots, and according to this approach, it is accepted that only diplomas and certificates are not enough (Zengin, 2022). In addition to the diplomas that individuals have, being competent in the field they work in, being open to continuous learning, being productive in the digital change processes in the world in a global context, being a designer, being able to produce solutions, being able to adapt quickly to technological changes, and having flexible skills are reported as necessary criteria for them to be preferred in the business world (Zengin, 2022). In this context, the adaptation of STEM education to the education system is important.

STEM is an acronym derived from the English words science, technology, engineering, and mathematics. Although the acronym STEM commonly refers to certain disciplines (Science, Mathematics) and professions (Engineering, Technology), there is still debate about what exactly these disciplines and professions are (Gonzalez & Kuenzi, 2012). Individuals with STEM knowledge and equipment solve problems using the information they have learned and develop critical thinking and higher-order thinking skills (Morrison, 2006). This approach encourages students, enables them to reach their aspirations, and provides them with the opportunity to apply what they have learned. It is stated that STEM education practices contribute to students' creativity, increase their self-confidence, and better understand and express the nature of technological developments through engineering studies using their knowledge and skills (Morrison, 2006). It is thought that the skills that students acquire in STEM education are related to 21st-century skills (Li & Schoenfeld, 2019).

Economic competition and environmental issues in the global market have made STEM education important. STEM education has also changed the education systems and curricula of countries in the economic race. Global problems have increased the demand for labor requiring STEM education.

STEM education approach practices vary considerably according to the level of education. At the primary school level, the focus is more on increasing performance and participation in science and mathematics curricula that are required for everyone. As the level of education increases, the content of the curricula includes more specific information about the relevant field of science and the sciences referred to by the acronym STEM can be specialized into sub-disciplines. For example, at the primary school level, science courses are based on a curriculum for daily life that is necessary for everyone, while at the high school level, science specializes in sub-disciplines of physics, chemistry, and biology. In addition to teaching daily life skills, students are also taught higher-level skills specific to the discipline. In this case, it should not be overlooked that STEM education practices are expected to be implemented at the primary school level, and STEM practices at high school, undergraduate, and graduate education levels are not the same; they should be specialized in accordance with the relevant education level. There are scientific studies that suggest a classification of STEM fields at levels other than the primary school level and that the STEM abbreviation should be made in accordance with the level of education in line with this classification (Xie & Killewald, 2012; Xie et. al., 2015).

STEM is easier to implement in primary schools because the subjects of physics, chemistry and biology are gathered in a single program under the name of science. Also, as a result of the fact that students are taught by a single teacher in primary school, teachers can freely develop and implement STEM learning designs (Roberts, A., 2012). The situation is different at the high school level. In addition to the curriculum not being thematic, each course is taught by a different teacher. Therefore, the integration of STEM into the curriculum at the high school level is more challenging. Creating a curriculum structure that integrates STEM elements across disciplines in this existing curriculum requires a long time and in-depth analysis. In countries with STEM-based curricula, this process has taken decades (Dugger, 2010). The best way to implement STEM in high schools is to use the embedded STEM approach. In this approach, an everyday or real-world context is needed as a learning theme. Through these contexts, students can use their cognitive gains to perform context-related activities through problem-solving.

Although different methods have been proposed for the implementation of STEM education, in general, the application starts with the presentation of a problem from daily life to students. Chemistry is a science related to real life. Presenting the subjects in the form of real-life problems enables students to understand the subject better and to be better prepared for similar situations in the future (Savery, 2015). It has been stated that problem-based learning (PBL) applications in chemistry teaching improve students' skills in using information sources, working in cooperation with the group, and contribute to students' high motivation and positive attitude toward chemistry courses (Tüysüz et al., 2010; Tosun & Taşkesenligil, 2012); increase the retention of the subjects taught and provided important advantages such as communication, problem-solving, and self-learning (Tatar et al., 2009). There are many studies showing that PBL applications in chemistry teaching improve students' problem-solving skills (Şenocak, 2005), logical thinking skills (Kumbasar, 2019), scientific process skills, and academic achievement (Tüysüz & Demirel, 2020).

In the traditional approach, students only receive information from the teacher to solve the problems given to them, whereas in PBL, after the problem situation is given, students become aware of what they are learning and why. In this approach, students reach the targeted information while solving the problem and, similar to the work of a scientist, identify the problem situation, collect the necessary information, and try to reach a conclusion (Tosun & Taşkesenligil, 2012). PBL is a method of learning in groups and individually that encourages students to conduct research to solve real-world problems, rather than teachers delivering lessons in the form of presentations and students trying to learn topics from textbooks (Sönmez & Lee, 2003). In PBL environments, the teacher coaches students in collaborative work and product design processes (Black & Wiliam, 1998; Hattie & Timperley, 2007).

The Chemistry Curriculum, published by the Ministry of National Education in 2024, is structured to shape the undergraduate and graduate studies of students interested in basic sciences (science for science) or engineering (science for society) (MEB, 2024). In the Chemistry Curriculum, the concept of STEM is emphasized explicitly rather than implicitly, unlike previous curricula. For example, the 9th grade chemistry curriculum includes the following statements (MEB, 2024).

> “Students may be asked to come up with designs for cleaning discharge water. For this purpose, students can be made to do an activity where they can apply STEM steps. Students can be asked to identify the waters polluted by domestic, agricultural or industrial wastes in their environment.”

In order for chemistry teachers to plan and conduct their lessons in accordance with the Chemistry Curriculum, they need to have knowledge about STEM activities. Therefore, it is important to provide teachers with examples of STEM activities. There are many studies in the literature on STEM applications in chemistry education. Some of these studies are summarized in Table 1.

Table 1.

STEM applications in chemistry education

Researchers	Participant/Sample	Activity
Tarkın-Çelikkıran & Aydın-Günbatar (2017)	13 chemistry teacher candidates	4 activities: Design of cold compress bag, Making indicator, Measurement of CO2 in aquarium, and Preventing browning of apples
Bruce, et. al, (2016)	419 university students	Students build a spectrometer to explore infrared radiation and greenhouse gases in an inquiry-based investigation to introduce climate science in a general chemistry lab course.
Tamburini, et. al (2014)	6 high school students	6 Modules: Paper Pulping and Floatation De-Inking, Enzymatic Digestion, Fermentation, Oligomerization, Lactide Formation, and Polymerization
Marle, et. al. (2014)	33 high school students	It is an application made in summer camp. Students visited the chocolate factory and collected data from the artificially prepared scene. Students also did activities related to methods Chromatography, GIMP Analysis, and Stereomicroscopy
Burrows, et. al. (2014)	106 high school students	A lesson plan has been prepared to be applied in biology and chemistry courses. All of the topics are related to the biodiesel production process.

If the studies in Table 1 are examined in detail, it is seen that most of the activities focus on specific topics. Almost none of these specific topics are in the chemistry curriculum. Chemistry teachers in Turkey may not use these activities very much. Therefore, the number of activities that can be done with simple materials and suitable for the topics in the chemistry curriculum should be increased.

The aim of this study is to introduce a STEM activity in accordance with the problem-based teaching method focused on chemistry course prepared to develop 10th grade students' entrepreneurship and scientific process skills.

2. Implementation Stages of The STEM Activity

The chemistry course-oriented STEM activity designed in accordance with the PBL method was carried out by taking engineering design steps into consideration. After obtaining the necessary permissions, the activity was applied to twenty-five 10th-grade students. The students were studying at a school in a good socio-cultural area in the capital of Turkey. The implementation of the activity took 4 class hours of 40 minutes each. The materials used in the activity are listed in Table 2.

Table 2.

Equipment and the materials used in the activity

Solutions	Other Materials
0.1 M Hydrochloric acid (HCl)	pH meter
0.1 M Sodium hydroxide (NaOH)	Erlenmayer
1 M Acetic acid (CH3 COOH)	Beherglas
Concentrated ammonia	Test tubes
Lemon juice	Tube Holder
Bleach	Graduated cylinder
Detergent water	Glass pipette
Pure water	Glass rod
Red cabbage juice	Pet bottle
	Duct tape
	Scissors
	Colored cardboard

The activity starts with a picture, followed by a brief explanation about the importance of food poisoning and smart packaging labels used abroad that provide direct information about the freshness of food. Then, the short story of a family who had to leave home for a long time for vacation was given. Upon returning from vacation, the family was unsure about the freshness of perishable foods such as meat and milk in their fridges. Although the expiry date has not expired, the family suspects that during the time they were away, they were exposed to an adverse condition, such as a power outage, which could have caused the food to spoil unobservably.

2.1. Defining Problem

This is the stage where students brainstorm after reading the short information and the story in the activity introduction to find out what the problem is under the guidance of the teacher. At this stage, the question "How could there be a packaking that would allow us to understand whether meat and dairy products are spoiled or not?" was asked to students and their answers were written on the board without criticism. Then, each answer written on the board was discussed and the logical ones were determined. This stage, which was carried out to determine the boundaries of the problem and to ensure that students internalize the problem, lasted approximately 10 minutes.

2.2. Analyzing the Problem

At this stage, students were first asked how they could tell whether meat and dairy products were spoiled or not. Then, in order to develop students' scientific observation and classification skills, they were given samples of fresh meat, spoiled meat, fresh milk, and spoiled milk and were asked to examine the samples, describe the characteristics of each of them, and classify them according to the differences in their appearance. Students recorded the results of their observations in the space allocated in the STEM worksheet. Scientific observation is the foundation of scientific process skills. People's need to observe their environment activates their sense of curiosity and triggers their desire to understand the world. Observation is defined as the process of using the senses to obtain information about objects and events in the environment. Observation, which is accepted as an important skill in the scientific process, is considered to be the essence of science as it forms the basis of other scientific process skills (Martin, 2003, pp. 65-66).

Another science process component that students try to develop at the problem analysis stage is prediction based on scientific observation. This skill involves drawing conclusions from observation data to justify their predictions by comparing observational and non-observational examples. In order to develop this skill in students, the following questions were written on the STEM worksheet, and students were asked to answer them.

- With which of your senses can you tell if food is spoiled?
- How do you determine whether meat and dairy products are tainted in a dark environment?
- Imagine that you have temporarily lost your sense of smell due to illness. What observations would you make to guess whether meat and dairy products were spoiled? Which observations would lead you to conclude that the meat and dairy products were spoiled?

Another science process skill focused on at this stage is operational definition. In order to help students acquire this skill, which is also known as transforming concepts into variables, an activity to determine whether various substances are acids or bases with a cabbage juice indicator was conducted in class. In this activity, students were asked to add hydrochloric acid, sodium hydroxide, acetic acid, concentrated ammonia, lemon juice, vinegar, bleach, detergent water, and distilled water to the flasks in which they put equal amounts of cabbage juice and observe the color changes in the solutions. Students used the observation data to classify the solutions as acidic, neutral, or basic and tried to estimate the pH values of the solutions as less than 7, 7, or greater than 7.

After the activity was completed, the class was informed that meat and dairy products produce acidic and basic gases when they are spoiled. They also discussed how to understand whether meat and dairy products are spoiled without opening their packages. This phase lasted approximately 30 minutes.

2.3. *Explaining the Problem*

This is the stage where students write a testable problem statement from the inferences they make and the data they obtain. In order to write a good problem statement, it is necessary to know what is known, what is expected, and what is available. For this, first of all, it should be determined how the topic has been examined before and what new studies are needed. For this reason, the students decided what they would investigate by discussing what they knew about the topic in the group and what they had learned from their observations and experiments. Students investigated the reactions that take place when food spoils and the gases that are produced as a result of these reactions and collected information about packaging technologies that show whether food spoils or not, depending on the pH change.

After the literature review was completed, students were asked to read the criteria and limitations in the STEM worksheet (Table 3). Finally, the students who had reviewed sufficient resources and, read the criteria and limitations discussed in the group and wrote the problem statements on the STEM worksheets. This application took about 15 minutes.

Table 3.

Criteria and limitations are written in the worksheet about the STEM activity

Criteria	Limitations
At least 100 mL of liquid should be placed in the container you will design	Only the following materials can be used when designing the container.
The container you design should be able to hold both meat and milk	500 mL Pet water bottle Strainer paper
The container you will design should not leak solid, liquid, or gas	Red cabbage juice Duct tape and decoration materials
The container you design must be aesthetic	The time allocated for the design of the container is 30 minutes.

2.4. *Solutions*

The scientific process skills focused on at this stage were hypothesizing and identifying variables. In order to help students acquire these skills, a demonstration experiment was first conducted with a pH meter. In this demonstration experiment, equal volumes of water with the same temperature were placed in two beakers, and the pH values of the waters were measured using an identical pH meter. Then, 5 mL of 0.1 M HCl solution was added to one of the beakers, and 10 mL of 0.1 M HCl was added to the other beaker, and the pH values were measured again. Finally, the results of the measurements were written in the table drawn on the board, and the dependent, independent, and control variables were discussed in the class.

After the demonstration experiment, students were asked to think of possible solutions to the problem they had identified. They wrote their solutions as hypotheses on their STEM worksheets. They were also asked to identify the dependent, independent, and control variables in their hypotheses. This phase took approximately 10 minutes.

2.5. Consider Alternative Solutions

At this stage, each student explained their solution proposals for the problem they had chosen, their hypothesis, and the variables in their hypothesis to their groupmates. The groups decided on the best solution proposal by considering the criteria, limitations, and variables. This phase took approximately 5 minutes.

2.6. Modeling the Prototype

This is the stage in which the students think about and model the prototype using the materials given to them. Students drew the model of the prototype they designed at this stage on their STEM worksheets. This phase took approximately 10 minutes.

2.7. Preparing the Prototype

The groups were divided into small groups to prepare their prototypes. Some students in the groups prepared their indicator papers. For this, they first cut the filter papers into different shapes according to their designs. Then, they soaked the cut papers in red cabbage juice and dried them.

The other members of the groups prepared the plastic water bottles. They made small holes in the plastic water bottle according to their designs. The indicator paper prepared by the first group was placed on the hole and wrapped well with duct tape. In this way, it was tried to prevent the substance to be put into the plastic bottle from leaking out. Finally, the groups finalized their designs by decorating the containers they prepared with decoration materials. This stage took approximately 15 minutes.

2.8. Testing the Prototype

The science process skill focused on at this stage was experimentation. Students were asked to design an experiment to determine whether the prototype they prepared was fit for purpose. They were told that food would take a long time to spoil and that it would not be possible to observe this during class time, and they were told to think of alternative materials they could use in the experiment. Through teacher-led class discussions, it was decided that acetic acid and concentrated ammonia vapor could represent the acidic and basic gases produced by spoiled foods and that acetic acid and concentrated ammonia solutions could be used in the experiments. The teacher then gave the students containers of solutions that they did not know what was in them. The students conducted experiments using their prototypes to determine whether the substances given to them were acids or bases. The students poured the given solutions into their prototypes, closed the cap of the bottle, and started the stopwatch. As soon as they observed a color change in the indicator (Figure 1), they stopped the stopwatch and recorded the time in a table, as in Table 4. Before each trial, the filter paper impregnated with the indicator that had changed color on the prototype was removed and replaced with a new one. When some groups tested their prototypes, they could not observe the color change clearly because there was gas leakage where they glued the filter paper impregnated with the indicator. This stage took approximately 15 minutes.

Figure 1.

Color change on indicator-impregnated filter paper in one group's prototype

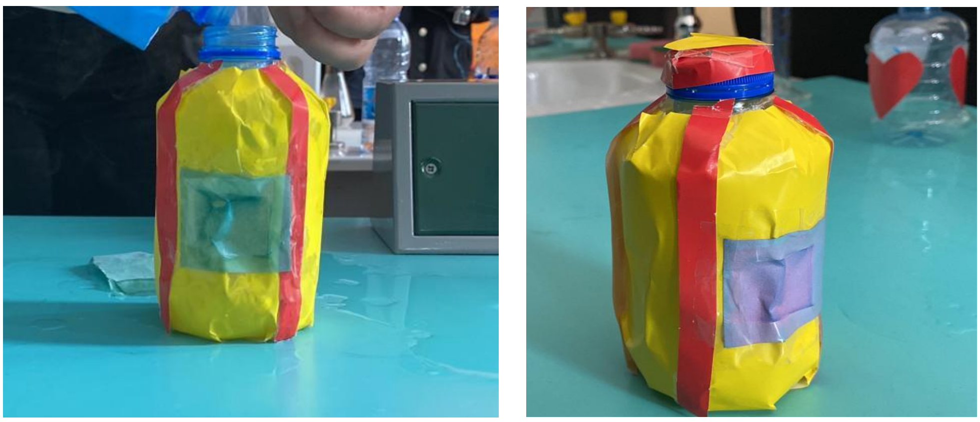

Table 4.

Example of a table in the STEM worksheet where groups record the results of the experiment

Experiment No	Independent Variable	Dependent Variable (Indicator color change time)	Observed Change

2.9. Test-Improve

This stage is the stage where the designs are reviewed, and necessary improvements are made in light of the data obtained from the experiments. The time allocated for this stage of the proposed activity is 10 minutes. Students discussed within the group and decided what kind of changes they would make in their designs. For example, some groups observed that a single layer of filter paper was punctured and used two layers of filter paper in their new designs. This phase took approximately 10 minutes.

2.10. Marketing the Prototype

At this stage, students were asked to promote and market their products in order to develop their entrepreneurial skills. For this, students first answered the following questions as a group.

- Think about what distinguishes your product from similar products. What are the advantages of your product?
- What is your advertising message?
- Explain your advertising strategy.

The students then prepared a poster for the promotion and marketing of their smart packaging and presented it to their classmates. This stage took approximately 20 minutes.

2.11. Evaluation

The students evaluated the smart packaging prototypes. In order for the evaluations to be objective, first of all, a measurable and observable scoring key given in Table 5 was prepared with the students for each criterion listed in Table 5.

Table 5.

The scoring table was created with the students to evaluate the prototypes

Criterion	2 Points	1 Point	0 Points
The volume of the container	Even if the container lies on its side, 100 mL of liquid can be poured into the container without leaking.	100 mL of liquid can barely be poured into the container without lying	The container cannot hold 100 mL of liquid.
Substances that can be placed	The container can hold both meat and milk.	Only milk or meat is put in the container.	No milk or meat can be put in the container.
Robustness	The container does not leak solid, liquid, or gas.	The container does not leak solids or liquids.	The container leaks solid, liquid, or gas
Aesthetics	At least two different colors are used in the decoration	A single color used for decoration	No decoration

Students presented their prototypes with their group in front of other groups. Students scored the prototype of the presenting group using the prepared scoring key. The scores of the groups were written on the board. Each member of the group with the highest score was given a chocolate bar as a reward. This phase took approximately 20 minutes.

3. Results

Students' opinions about the activity were collected through the activity evaluation form, the items of which are given in Table 6.

Table 6.

Frequencies and percentages of students' opinions about the activity

Item in the activity evaluation form	Student views I agree. f	%	Undecided f	%	Disagree f	%
The activity is engaging.	20	83,4	2	8,3	2	8,3
The activity helped me understand the topic of acids and bases.	20	83,4	1	4,2	3	12,5
I think my entrepreneurship skills have improved by participating in the activity.	8	33,3	14	58,4	2	8,3
In the future, I would like to start a company that sells the products we have designed.	9	37,5	8	33,3	7	29,2
I think my problem-solving skills improved by participating in the activity.	15	62,5	6	25,0	3	12,5
By participating in the activity, I learned about the spoilage process of meat, milk, and its products.	22	91,7	2	8,3	0	0,0
I would like similar activities to be done more often in chemistry lessons.	18	75,0	2	8,3	4	16,7
By participating in the activity, I understood what indicators are for.	21	87,5	1	4,2	2	8,3
By participating in the activity, I learned about some laboratory materials.	15	62,5	5	20,8	4	16,7
Working in a group was more productive than working individually.	16	66,7	5	20,8	3	12,5

Table 6 shows that 83.4% of the students found the activity introduced in this article interesting. According to the Table 6, the majority of the students stated that they understood the acids and bases topic better through the activity and that they had information about the spoilage process of meat, milk, and their products. 75% of the students wanted similar activities to be done more frequently in chemistry lessons. This finding is in line with informal classroom observations. Most of the students tried to do the activities even during breaks, and even students who were generally not interested in the lessons actively participated in the lessons.

According to Table 6, 58.4% of the students are undecided about the development of their entrepreneurial skills. This finding is consistent with the data in the item "I would like to establish a company to sell the product we designed in the future." However, it cannot be said that STEM activities do not develop students' entrepreneurial skills just by looking at this data. This study introduces the activity used in a doctoral dissertation in which the effect of STEM activities on the development of science process and entrepreneurship skills of 10th-grade students was investigated. In the thesis study, students did four different STEM activities. At the end of the activities, the development of students' entrepreneurship and science process skills were measured with standardized measurement tools.

Another important finding in Table 6 is that 62.5% of the students think that their problem-solving skills have improved. As it is known, problem-solving skills and scientific process skills are interrelated. Therefore, students' scientific process skills were also improved thanks to the activity. This finding is supported by the data in the item "Thanks to the activity, I gained knowledge about some laboratory materials" because one of the scientific process skills is to recognize and use the experimental materials correctly

4. Discussion and Conclusion

This study presents an engaging STEM activity that can be used to teach acids and bases to 10th-grade students. The activity was aimed at developing students' science process skills and entrepreneurial skills. During the implementation of the activity, students used various laboratory materials, identified the problem, and developed solutions to the problem with the scenario given to them and the questions and directions directed to them, and used their scientific process skills in design, production, and marketing processes. The presented STEM activity enabled students to acquire scientific process skills by doing and experiencing without realizing it. The results of the study are consistent with the literature. It has been reported that STEM activities applied with problem-based teaching method improve students' scientific process skills (Aprianty et al., 2020; Jewaru, et al., 2022). It was found that students who participated in STEM activities developed for chemistry courses significantly increased their academic achievement and creativity (Ridwan et al., 2017; Tunkham et al., 2016).

In the presented practice, students worked in groups from the beginning to the end of the activity. Students who voluntarily shared tasks within the group in line with the teacher's instructions experienced important skills such as taking responsibility, communicating, and working as a team. In line with the roles that each student has in the group, career development can be contributed to by directing them to conduct research on professions. There are studies showing that STEM education significantly increases students' academic achievement and improves their career interests positively (Çevik, 2018).

In this activity in which the engineering design cycle was used, students realized the deficiencies and mistakes in the design after testing the prototypes they created. These realized deficiencies and errors can be characterized as new sub-problems that emerged as they progressed through the activity steps. For each problem they noticed, the students reinforced their scientific perspective by going through the stages of recognizing the problem, expressing the problem, brainstorming, proposing solutions, problem-solving, reasoning, testing, and developing in a cycle of processes similar to the process they followed from the beginning of the activity. This information is in line with studies showing that STEM activities increase high school students' scientific process and engineering skills (Khamhaengpol et al., 2021). There are also research findings in the literature that STEM activities increase students' awareness about the importance of the engineering profession and engineering skills (Popa & Ciascai, 2017). Teachers can inform students about laboratory materials, methods and techniques, and safety rules during STEM activities. In addition, the implementation of STEM activities in chemistry lessons can provide many advantages, such as enabling students to try cheap materials that are easily available in the design and production stages and to gain skills such as recognizing materials and developing hand skills.

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