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Designing for Entrepreneurship: STEM-Based Approaches in Primary Education

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Abstract

This study aims to enhance primary school students' entrepreneurial skills by integrating STEM education. Employing a qualitative action research design, the study involved 19 fourth-grade students (aged 9–10) selected via convenience sampling. Over a six-week period totaling 18 instructional hours, researchers implemented two STEM-based activities aligned with the study's objectives. Data were gathered from multiple sources, including video recordings, e-portfolios, student journals, researcher journals, and student-generated artifacts. The research was guided by a framework encompassing 22 entrepreneurial skills, categorized into three domains: knowledge, skills, and attitudes. Findings indicate that while students did not demonstrate complete competence in all areas, particularly within the entrepreneurial aptitude domain, they showed notable development in their understanding, practical skills, and attitudes related to entrepreneurship.

Keywords

Entrepreneurial Skills, Engineering-Design, STEM Education, Action Research, Primary Education

Background

To effectively compete in the global arena, students must possess comprehensive 21st-century skills (Cansoy, 2018; Duman & Aybek, 2003; Yalçın, 2018; Yüksel, 2019). These skills, including critical thinking, entrepreneurship, problem-solving, collaboration development, initiative-taking, and communication, are essential for success in today’s world. As unemployment increases, individuals must be able to adapt to rapid advancements in science and technology. Entrepreneurship skills have gained significant importance, and incorporating entrepreneurship education into the school curriculum can foster career awareness (Raposo & Paco, 2011). Further research and pilot studies are necessary to determine the most effective learning methodology. While the school curriculum in different countries incorporates entrepreneurship skills, there is a lack of specific details for primary schools. Scholars propose analyzing national methodologies and adapting those to local contexts to acquire 21st-century skills (Ekici et al., 2017; Gelen, 2017). Consequently, understanding how entrepreneurship education is conceptualized and practiced in various educational systems provides valuable insights for developing effective and contextually relevant approaches. This allows for successful applications while avoiding ineffective activities or programs. Varied interpretations of entrepreneurship education led to diverse implementation approaches in European countries (EACEA, 2016). The extent of entrepreneurship varies based on socio-cultural environments (Kelly, 2020; Sawyer, 2012).

Conceptual Framework

Entrepreneurship in Primary School

Teaching entrepreneurial skills at all levels of education, particularly from primary school, is crucial for cultivating entrepreneurial individuals who can meet the demands of a rapidly changing and evolving world (Yurtseven, 2020). Entrepreneurship education in primary school focuses more on encouraging basic skills such as creativity, curiosity, problem solving, communication, and teamwork, considering that students are not developmentally ready to understand abstract economic concepts (Lackéus, 2015). Integrating entrepreneurship skills into primary school curricula aims to enhance students' career awareness (Herdem & Ünal, 2018; Raposo & Paço, 2011). Field trips, observations, and expert meetings can boost career awareness (Selanik Ay & Acar, 2016). Primary school students should learn foundational entrepreneurial elements, including favorable attitudes, essential abilities, hands-on learning, exploring personal interests, and developing entrepreneurial behavior and skills (Barba-Sanchez & Atienza-Sahuquillo, 2016). Entrepreneurship is considered not only as a process that produces economic output, but also as a multidimensional mental structure involving creativity, recognizing opportunities, risk assessment, and innovative problem solving (Lackéus, 2015). The development of entrepreneurial skills at the primary school level plays a crucial role in helping students acquire fundamental skills, such as problem-solving, creativity, communication, and collaboration, at an early age (Ministry of National Education [MoNE], 2018). Academic research examines the factors that influence teaching entrepreneurial skills to students. Deveci and Çepni (2014) suggest that creating suitable environments for skill acquisition fosters entrepreneurial development. While some studies suggest entrepreneurship has an inherent element, others present contrasting findings. Yurtseven and Ergün (2018) emphasize that the primary goal of entrepreneurship education is to acquire or enhance entrepreneurial competencies in cases where they are lacking. Yurtseven (2020) classified content related to primary school students' entrepreneurial skills under the headings of knowledge, skills, and attitudes (see Figure 1 for the list). Individuals with entrepreneurial aptitude are crucial for innovative thinking and transforming concepts into tangible results, such as creating original merchandise. Effective communication skills are also essential for interacting with relevant individuals or institutions. In this respect, entrepreneurship education is considered a process that should be initiated at the primary school level to enable students to gain career awareness and develop innovative thinking skills (Deveci & Çepni, 2014; Hardie et al., 2020; Yurtseven, 2020).

Entrepreneurship and STEM Education

The significance of production and innovation has increased in our dynamic global landscape, driven by heightened consumption. Technological advancements have increased global interconnectedness, making changes in one country have significant implications for others. To remain competitive, countries must adapt. Ağca and Yumuşakipek (2015) assert that innovation is driven by knowledge, technology, and technological advancements. Countries at the forefront of global competition incorporate STEM education into their curricula. STEM education effectively responds to evolving demands. Education must continually adapt to sustain its strength in the face of technological advancements, product variations, changing consumption patterns, evolving production methods, and shifting scientific disciplines. Karahan et al. (2014) found that high-quality STEM education provides students with STEM literacy and essential 21st-century competencies, including problem-solving, critical thinking, and

teamwork. Recent research indicates that STEM education is crucial to the economy (Tekbıyık & Çakmakcı, 2018).

Entrepreneurship, as defined in various sources, involves multiple subdimensions and requires interdisciplinary collaboration (Kelly, 2020; Yüksel, 2019). According to Vesper and Gartner (1997), the duration of entrepreneurship education is crucial for acquiring and developing entrepreneurial skills (Tarhan, 2019a). The existence of sub-dimensions of entrepreneurial skills may necessitate that these skills be taught in an integrated manner. Teaching these skills within the school, if there is no specific course dedicated to this subject, necessitates an activity framework integrated into the course content. A well-planned activity process will be valuable in terms of developing these skills. Entrepreneurial skills influence work principles in STEM activities and contribute to the value of products. Entrepreneurship cultivates creativity, management, planning, problem-solving, innovation, and risk-taking. It also addresses economic implications and marketing strategies. Presenting a case study to students and designing a product to solve the problem, determining the market value of this product, and preparing a user manual for the product are activities that are expected to be effective in developing these skills. Aydoğdu et al. (2020) emphasize the importance of cultivating entrepreneurship skills for appreciating product value in STEM activities and effectively executing marketing strategies.

Integrating entrepreneurship skills into STEM education through interdisciplinary approaches enhances individual development and product quality. STEM education fosters career awareness by integrating knowledge and proficiencies from various disciplines in practical endeavors. Herdem and Ünal (2018) found that career awareness is integrated as an intermediate discipline in primary school education, and STEM education is crucial for developing this awareness in STEM fields. Entrepreneurship requires innovative thought processes. Promoting innovation is vital for economic growth, and STEM education, the foundation for innovation, can achieve this.

Innovation manifests in creative and unconventional thinking, as highlighted by Kelly (2020). Kuhn (1991) emphasized the need for paradigm shifts to disrupt the status quo. For innovation to occur, it is necessary to step outside the box and think outside the lines. The comfort that individuals/societies find in the standard hinders the realization of innovations. Deveci and Çepni (2015) identified novel idea generation as a fundamental entrepreneurial trait. McDaniel (2002) defined it as transforming novel concepts into marketable products or services through entrepreneurial efforts. Researchers focus on cultivating novel concepts and pursuing innovation. Entrepreneurship, involving sharing and launching novel ideas and products, is central to STEM studies, highlighting their synergy. Dinçer (2014) suggests that allocating resources to STEM skills can position nations in the global economy, influenced by sustainability and innovation enabled by science-oriented education, which directly addresses entrepreneurship education.

Several studies have focused on transmitting entrepreneurial skills to subsequent cohorts, emphasizing educators' entrepreneurial competencies and pedagogical expertise in fostering entrepreneurship abilities. Hassi (2016) highlighted the significance of curriculum design in early skill development. Seikkula-Leino et al. (2010) found that teachers play a crucial role in students' entrepreneurial skills. However, the goal and application guidance lacked clarity.

Yurtseven and Ergün (2018) suggested strategies like drama, brainstorming, project management, research-based learning, and problem-based learning to enhance teachers' entrepreneurial competencies. Tarhan (2021) emphasized the impact of inspiring entrepreneurs and using entrepreneurial narratives for career advancement. Floris and Pillitu (2019) advocated for a problem-oriented approach to entrepreneurship education in primary schools, involving policymakers and local stakeholders. Primary school studies are considered a strategic investment in early education. The integration of STEM education with entrepreneurial skills is important, particularly in primary education, in terms of its potential to support students' ability to generate innovative solutions to real-life problems.

Objectives

This research aims to develop STEM activity modules to enhance primary school students' entrepreneurship skills. The study evaluates the effectiveness of the modules. The activities were part of the "Let's Build Simple Electrical Circuits" and "Light and Sound Technology" instructional units. The research modified the Science and Mathematics curricular units to align with STEM education and implemented them in an extracurricular setting. Yüksel (2019) argues that an interdisciplinary approach is advantageous for acquiring entrepreneurial skills. The research inquiry examines the impact of STEM activities on the development of entrepreneurial aptitude among fourth-grade students (aged 9–10). The research questions were:

- How do STEM-focused activities affect 4th-grade students' entrepreneurship knowledge?
- How do STEM-focused activities affect 4th-grade students' entrepreneurship skills?
- How do STEM-focused activities affect 4th-grade students' entrepreneurship attitudes?

Methods

The primary objective of this study was to enhance the entrepreneurial skills of primary school students. The research methodology employed was action research, utilizing qualitative research designs. Due to the requirement of prolonged implementation in real-world contexts, the researchers concluded that prioritizing local concerns would yield more significant advantages (Aksoy, 2003; Yıldırım & Şimşek, 2018). The study specifically focused on developing entrepreneurship skills among primary school students. This study observed the development of students' entrepreneurial skills within the context of the problem statement presented throughout the research process.

Action Research Process

Diagnosis

The existing literature lacks a clear definition of entrepreneurship knowledge and skills for primary school students (Yurtseven, 2020). While the curriculum for 21st-century skills includes entrepreneurship skills, specific primary school-level sub-dimensions are lacking. This stage is the initial research phase, commonly referred to as the diagnosis stage.

Identification

After the diagnosis, specialists discussed the prevailing issue. To understand the problem, they systematically reviewed relevant literature from various sources. The investigation into entrepreneurship skills revealed that most studies focused on engineering and business

students (Çetinkaya Bozkurt & Alparslan, 2013; Dündar & Ağca, 2007; İşcan & Kaygın, 2011; Karslı, 2018; Keleş et al., 2012). Recent research has focused on entrepreneurship skills in education (Selanik Ay & Acar, 2016; Tarhan, 2019b; Yılmaz & Sünbül, 2009). Integrating entrepreneurship skills into primary school education is a relatively recent development, prompting research on the acquisition of these skills (Akbayrak, 2019; Karakılçık, 2020; Tarhan, 2021; Yurtseven, 2020; Yurtseven & Ergün, 2018). However, there is a lack of comprehensive empirical data on specific sub-dimensions of entrepreneurial skills.

Development

To address the problem of increasing national demands and a lagging economy, educational institutions must equip students with practical skills for real-world scenarios. Ememe et al. (2013) found that students lacked readiness for life, hindering their employment prospects. Including entrepreneurship skills in the curriculum can address this issue. Recent graduates who establish businesses often lack essential entrepreneurial skills, which can lead to the failure of their enterprises. A structured curriculum can cultivate entrepreneurship skills. Tarhan (2019a) emphasizes the need for individuals to acquire entrepreneurial skills to create new employment opportunities. Instruction in entrepreneurship skills should begin in preschool, fostering creativity and collaboration.

The literature on entrepreneurship studies equips students with skills and knowledge to succeed in real-life challenges, just as STEM studies do. Kuratko (2005) emphasizes the importance of technology in entrepreneurship. An early 2000s study highlighted the need for adopting the STEM approach in education to prepare students for entrepreneurial endeavors in the 21st century. STEM skills reinforce this necessity. The Turkish Ministry of National Education's 2018 guidelines for 4th-grade science textbooks include activities titled ‘Science, Engineering, and Entrepreneurship’, which equip students with real-world skills and allow them to showcase their designs at the annual science fair. The curriculum's focus on 21st-century skills equips students with the competencies to navigate contemporary life and critically evaluate their outcomes.

Development of an Action Plan

Researchers employed STEM-based activity modules with fourth-grade students to develop entrepreneurship skills, utilizing two Science units that integrated technology, engineering, and mathematics. Students solved a problem scenario involving a natural disaster and created two potential solutions as products. The first product resolved the issue, while the second was a district map on which they placed the product. Table 1 presents the distribution of activity modules and outlines the skills emphasized within the modular scope during action research.

Table 1. Skills Targeted in the Modular Scope during the Action Research Process

Purposes	Technology Skills	Entrepreneur Skills	Engineering Skills
Module 1: Understand and visualize the problem situation.	Creative Communicator Global Collaboration Digital Citizen	Creativity and Innovation Management Skills and Leadership Planning	Analyze and Interpret Data
Module 2: Identifies the environment where the problem occurs and the weather conditions that cause the problem, and creates a graph accordingly	Global Collaboration Digital Citizen	Creativity and Innovation Problem Solving	Information gathering, evaluation, and communication
Module 3: Sound technologies, inventors, and the periods in which they lived are researched. Research is presented on a poster	Computational Thinking Digital Citizenship	Creativity Leadership Planning	Information Gathering, Evaluation, and Communication
Module 4: Research what can be done to prevent inconvenience to the public in case of the collapse of electric poles, and seek expert opinions	Empowered Learner Digital Citizenship Knowledge Constructor	Innovation Creativity Problem Solving	Creating Explanations and Designing Solutions Analyzing and interpreting data Planning and Executing Investigations
Module 5: The generated draft product drawings are compared with the information on sound technologies discovered (considering the economic efficiency and lifespan of the products), and a decision is made on the best idea.	Creative Communicator Digital Citizenship Knowledge Constructor	Problem Solving Risk Taking Innovation Planning Creativity Management	Information Gathering, Evaluation, and Communication Analyzing and Interpreting Data Planning Investigations and Conducting

Module 6: The product is created.	Empowered Learner Digital Citizenship Knowledge Constructor	İnnovation Creativity Problem Solving Planning Taking Risk Management	Creating Descriptions and Designing Solutions Analyzing and Interpreting Data Planning Investigations and Conducting
Module 7: The user manual of the product is written.	Digital Citizenship Knowledge Constructor	Innovation Creativity Planning Management	Developing and Using Models Analyzing and Interpreting Data Planning and Conducting Investigations
Module 8: A city map is created, indicating the usage of the product based on all available information	Knowledge Constructor Empowered Learner Computational Thinking	Taking Risk Creativity Planning Management Problem Solving Innovation	Developing and Using Models Analyzing and Interpreting Data Planning and Conducting Investigations Information Gathering, Evaluation, and Communication Creating explanations and designing solutions

Implementation and Evaluation

As part of the action process, students were required to create two STEM products to address a problem in their immediate surroundings. The observation of entrepreneurship skills development was intended to be conducted through the students' creation of STEM products. On July 3, 2020, a landslide disaster in the Uzumlu district of Erzincan caused power outages by collapsing electricity poles. The students were tasked with analyzing the socioeconomic status of the local population and their familiarity with Uzumlu in their product design. The students formed groups and conceptualized and developed their products using computer software on a collaborative platform. In the initial STEM activity, "I am a Little Engineer," the groups strategically positioned their products on the Uzumlu map to monitor power outages. The following section presents the STEM activities and the respective activities of the groups.

I am a Little Engineer: Based on the primary education curriculum, specifically the unit on Lighting and Sound Technologies, students learned about a power outage caused by a landslide and its impact on the community. They were tasked with developing products that use lighting

and sound technologies to address the issue. Four groups strategically chose to use these technologies to reach a wider audience. They incorporated devices such as alarms, sirens, and lamps into their products and positioned them in fixed locations.

I am Planning My District: The "I am Planning My District" activity encouraged students to use the Uzumlu district map to plan their products. They applied mathematical skills to calculate expenses and understand how to distribute their products effectively within the community. Students provided a rationale for their product placement on the map. The cost was determined by multiplying the unit price by the quantity of products ordered. This calculation informed their decision to increase or decrease the quantity of products to be ordered.

Participants

The study involved the participation of fourth-grade students who volunteered for the research. The study recruited participants in groups of four, consisting of a total of 19 students from two different classrooms within the same school. The participants were selected utilizing a convenience sampling method. To facilitate convenient access for students and parents, the researcher employed this approach, as it allowed her to continue her research within the confines of her affiliated institution. Participants were assigned to groups labelled S1, S2, S3, up to S19. Group members decided the group names after they were assigned to their groups.

Table 2. Group Names and Students

Group Name	Students
Small Builders	S1, S2, S3, S4, S5, S6
Myth Team	S7, S8, S9, S10
Engineer Stars	S11, S12, S13, S14
The Best Engineers of the World	S16, S17, S18, S19

Data Collection Tools

The data was gathered via various methods, including focus group interviews, observations, e-portfolios, student journals, and researcher journals. The subsequent sections provide comprehensive explanations of each instrument used for data collection.

Focus Group Interview

The study used a group interview method focusing on a specific topic. Focus group interviews typically follow seven stages (Yıldırım & Şimşek, 2018).

1. Review research purpose and method.
2. Develop interview questions based on research problems.
3. Plan location and technology.
4. Pilot test the process.
5. Invite participants.
6. Conduct the study.
7. Organize and analyze data.

Participants in groups in Table 2 were interviewed four days a week. The interviews assessed students' knowledge, skills, and attitudes related to their ongoing activities. During the "I am a little Engineer" activity, students discussed the local community's needs and designed a product. They researched and developed a preliminary product draft. During the "I Plan My District" activity, groups discussed marketing strategies for their products. Students learned communication, technological proficiency, keyword identification, and problem-solving skills. Despite challenges with peers or unfamiliar software, they overcame them through learning.

Student Journals

According to Ören (2014), using student journals allows researchers to assess and comprehend the evolution of students' achievements, experiences, reflections, and dispositions toward the instructional content over time. Students must provide written responses in their journals following the conclusion of after-school activity sessions. These responses should address their perceptions of the activity, the knowledge they acquired, the stage of the activity that had the most significant impact on them, and the specific role they assumed in the distribution of tasks.

Researcher Journals

It is essential to promptly document actions, observations, and noteworthy aspects to ensure the study plan's progress. Çelik et al. (2020) posit that qualitative researchers have the opportunity to utilize research journals as a means to articulate and critically evaluate their ideas comprehensively. Utilizing the researcher's journals facilitated the retrospective examination and correlation of activities undertaken at the commencement and culmination of each procedural phase.

E-Portfolio

E-portfolios are educational tools that monitor students' progress and mitigate risks due to their digital nature. Soland et al. (2013) found that active e-portfolio use enhances self-awareness and fosters collaboration, learning to learn, communication, and application skills. Ravitz et al. (2020) emphasized the importance of active technology engagement for acquiring 21st-century skills. This study documented artifacts in students' e-portfolios, including product drafts, posters, city models, final products, and user manuals throughout the implementation process.

Observations

The documentation of observations was crucial for reporting the implementation process and student outcomes in the action research study. The researcher used video and audio recorders to enhance the detail of student interactions (Yıldırım & Şimşek, 2018). Weekly video recordings were made and transcribed for analysis.

Data Analysis

Acquiring entrepreneurial skills through the STEM approach requires a systematic and well-organized framework. The framework is presented in Figure 1. The research data were analyzed using a descriptive approach, as outlined in the framework. The categorization of entrepreneurship content involved three key components: knowledge, skills, and attitudes (Yurtseven, 2020). Figure 1 shows the classification of entrepreneurship based on knowledge, skills, and attitudes.

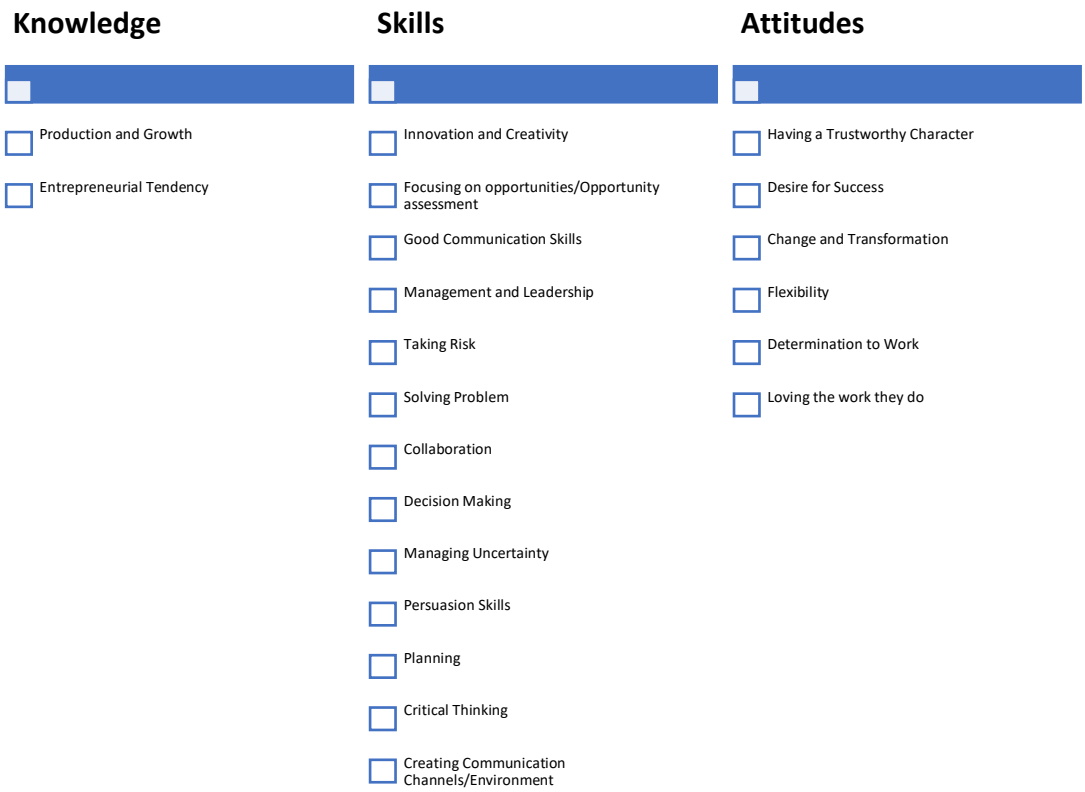

Figure 1. Classification of Entrepreneurship in Terms of Knowledge, Skills, and Attitudes (Yurtseven, 2020)

All procedures conducted in this action research study involving human subjects complied with ethical norms. The study was approved by the Eskişehir Osmangazi University Ethics Committee (Approval number: 2021-09). Informed consent was obtained to ensure that each of the fourth-grade participants voluntarily chose to participate in the research. Additionally, permission to publish research findings, including student-generated artifacts and identifiable data, has been obtained from both the study participants and their parental guardians. The data collection process, which took place outside the classroom, was conducted in the presence of the students' legal guardians.

Results

Knowledge

Production and Growth

The participants emphasized Production and Growth, and the researcher observed students' progress in this area. At this point, students adopted the perspective of the intended audience to address the problem. They adapted their knowledge to the problem's context and proposed potential solutions. For instance, they suggested creating two distinct designs to meet the needs of those facing the issue. The researcher detailed the situation in their scholarly journal.

> *After evaluating the products, they discussed their advantages and disadvantages. They suggested producing two products to offer the public options. (Researcher Journal)*

The students suggested implementing the designs they created, considering cost and usability factors. They asserted that the applicable designs could be implemented in various regions. S7 emphasized extending the warning system's implementation from a limited neighborhood to diverse neighborhoods for the dissemination of widespread information. They also advocated for adopting the system in various cities. S7's statement is presented as follows:

> *This is not very expensive, but it is slightly above average. It is for use between neighborhoods, but for large neighborhoods, such as this area, it can be used to connect to another far-away neighborhood. Someone living in another neighborhood can hear the sound but cannot see the light. This promotion should be conveyed to every province in Türkiye and exported. (S7)*

Entrepreneurial Tendency

The findings examined student progress in acquiring knowledge about entrepreneurial activities. Students designed individual products and grouped to determine the most exemplary one. Their goal was to create a cost-effective product accessible to a wide audience. Affordability and broader accessibility were key considerations. S16 designed a product while balancing profit maximization with environmental impact, utilizing their entrepreneurial skills. Their statements suggest this perspective.

> *Using a brighter light rather than a red light will be cheaper than my suggestion. Let us try changing the red to something else. (S16)*

The subsequent statement represents the decision made by S16 regarding the proposition to manufacture goods utilizing recycled materials.

> *Yes, it is possible. We can help the environment and reduce our carbon footprint together. (S16)*

Skills

Innovation and Creativity

The study found an increase in students' aptitude for innovation and creativity. S3 presented their independently developed sound and light warning system to peers and the researcher during the study's initial phase. S4's product, "I am a little engineer," was well-received by most of its target audience; however, S6 and S1 identified areas for further enhancement. The Little Builders team's claims focus on originality and imagination.

> *When the light is green, the risk is minimal. The siren emits a soft sound. When it is yellow, the threat is moderate. The sounds are slightly louder. I have marked three distinct siren tones in red for maximum coverage. (S3)*

S5 aimed to raise awareness of the disaster by utilizing existing products, such as a minaret, rather than building new infrastructure for a warning system. The following statements are based on S5's principles.

> *We installed streetlights and erected a single iron rod outside town, hundreds of meters away. The rod's camera detects oncoming floods, visible from anywhere in the city. A*

> *cable connects the ground to the rod, delivering the latest news to the mosques and streetlights. (S5)*

Focusing on Opportunities/Opportunity Assessment

Students' focusing skills, crucial for entrepreneurship, were developed through STEM activities. S8 discussed assessing water wastage, specifically identifying unnecessary consumption, to address the entrepreneur's issue of thirst during a STEM career study. The student's argument aligns with this approach.

> *I think the restroom, Ms. Teacher. When you flush, a lot of water goes down the drain. (S8)*

S12 discovered a solution to the aforementioned real-world dilemma:

> *Our mothers, for instance, often loaded the washer with too little laundry. Wasted water. (S12)*

The Small Builders group members noticed they could effectively expand their target market by assessing their products and diversifying their offerings.

> *After evaluating the products, the Little Builders group discussed their pros and cons by watching a video where S2 explained her product design for the "I am a Little Engineer" activity. The company claimed that they could produce two products for greater variety. (Researcher Journal)*

S19 and S18 collaborated to solve a problem and presented their product to the team. S19 also identified ways to ensure equitable access to their products for marginalized individuals.

> *Although it was designed with deaf people in mind, we will also add vibrations for the visually impaired. (S19)*

To highlight the extent of individuals' reliance on their mobile devices, S17 proposed integrating vibration functionality into their product design. Presented here is the statement of S17:

> *We set it to vibrate on the phone, so it falls out of their hand even if they cannot see it, since we know it will not fall out of their hands. (S17)*

Communication Skills

The study revealed a significant enhancement in the communication skills of the students. The Small Builders group members have conducted an assessment of S1's communication abilities and have documented the following observations:

> *It was noted that S1 was tense and rude to a few friends while conducting weather research and creating the graph. (Researcher Journal)*

> *Notably, S1 mellowed during subsequent dates, and after viewing the video of S2 introducing his product, he suggested that his friend give the presentation because of his superior communication skills. (Researcher Journal)*

S12 expressed their perspective on the significance of effective communication. Presented here is the explanation of S12:

> *Not only is there something similar, but it is also beautiful, can be accomplished without stuttering, and requires no explanation. There is a 98% chance of success if we take these steps. (S12)*

Management and Leadership

The evaluation of students encompassed an assessment of their advancements in management and leadership. The subsequent discourse comprises S4's communication to his team members concerning leadership and the recommended course of action they should adopt.

> *Hopefully, I will do it; we will both do it; of course, we will take turns. First, you will share some info, and then I will share mine. I will respond first if a question is posed to both of us. (S4)*

Furthermore, the research journals have verified that S3 allocated distinct responsibilities to each group member to create the poster.

> *S3 coordinated the poster study by determining who would write what, where, and how on the shared page. He was viewed as a leader due to his independent work style, which was generally well-received. The typical works of the students are listed below. (Researcher Journal)*

Taking Risk

Students' risk-taking capability was monitored. The Myth Team group considered revisiting problem-solving and product-design methodologies and presenting an alternative design if their product did not meet expectations. They also considered scenarios where their product might not be included, lack aesthetic appeal, or fail to meet expectations. Students shared their perspectives on their risk-taking tendencies.

> *We need to apply and notify them of floods, I believe. (S9)*

S5 assumed the task of composing the guide. Upon careful examination of the mandatory software, S5 developed a sense of apprehension regarding their ability to fulfil the assignment successfully. The following statement is pertinent to the discussion at hand.

> *S5 of the Small Builders team offered to write up the instructions. He was concerned about this problem after learning about the Canva program and suggested delegating the work. (Researcher Journal)*

S5 used Canva to create the user manual and shared it with friends before the six-day meeting with the Small Builders organization. The following is the researcher's recorded interview observations.

> *S5 consulted friends about the product's components and purposes before creating the user manual in Canva. Despite solving his problem, he took a chance by writing the manual himself. (Researcher Journal)*

Problem solving

The progress of the students was monitored about their problem-solving skills. S3 successfully resolved the issue by devising a solution involving a loud alarm system accompanied by flashing lights. In this matter, please consider the subsequent statement wherein S3 delineates the artifact he has created:

> *When green, the threat is minimal. The siren emits a soft sound. Yellow indicates a moderate threat. Medium sounds are slightly louder. I will color-code three siren sounds in red for universal recognition. (S3)*

S6 discussed their intention to incorporate provisions for individuals with disabilities during the development of their inaugural product.

> *This idea came to me because I mentioned that some people have trouble hearing or seeing, and others prefer to listen to music through headphones. (S6)*

S2 elucidated the product's layout in the accompanying video clip. Figure 2 shows the students' design of their product.

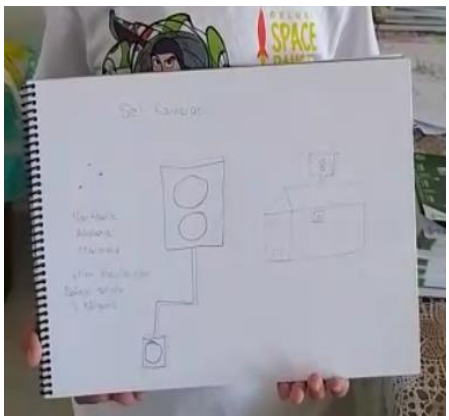

Figure 2. Student Product Design

S11 demonstrated considerable effort in overcoming the challenges encountered in his academic pursuits despite the lack of recognition from his educators and peers for his problem-solving skills throughout the academic term.

Collaboration

The participating students' progress was assessed on their teamwork skills. The first member of the Small Builders crew successfully overcame obstacles through collaborative effort. S16, a member of the "Best Engineers in the World" group, actively sought feedback from authoritative entities about his designed product. Here is S16's statement on the matter:

> *Teacher, I have created a product that protects against any natural disaster, not just floods. I even consulted my dad's co-workers, and they shared their thoughts.*

The researcher demonstrated Canva, a software tool, to the participants. They designed a group logo using a shared computer. The text below presents a statement.

> *Students in The Best Engineers in the World used Canva for their project. She demonstrated the program, and students worked on their own devices, showing each other their screens and collaborating on a logo. (Researcher Journal)*

Figure 3 shows the logo prepared by the The Best Engineer of the World group.

Figure 3. The Best Engineer of the World group logo study

Managing Uncertainty

When determining the cost and profit of the product, member S17 employed their expertise in managing uncertainty to make informed estimations. S17 puts forth the following claims:

> *If a high-quality speaker costs 700 lira, then a pleasant vibration device should not cost less than 500... 16,800 lira. I will cross out the nearby locations. (S17)*

The presentation delivered by the Small Builders group was characterized by a pervasive sense of uncertainty, which can be attributed to their inadequate level of preparation. The following is the transcript of the group's conversation:

> *When the floods come, we have a vehicle to get the word out. (S6)*

> *To explain, the user guide must first be displayed. Let him (S5) show. (S4)*

Decision Making

The researchers observed the students' decision-making skills. They established a friendly environment for discussion, thanks to their positive relationships, and collaboratively reached decisions on their designs. Despite design preferences, they developed a cost-effective collective design. The Engineer Stars group investigated the advantages and disadvantages of solar energy. After evaluating the information, they decided to use solar energy as a viable option due to its affordability. The results are presented below.

> *The Engineer Stars group chose the solar panel due to its environmental friendliness and cost-effectiveness, as learned from the engineer's knowledge of energy conversion. (Researcher Journal)*

The Small Builders group has acquired many product designs. They must decide which one to showcase effectively. Here is the researcher's journal statement about decision-making.

> *The Small Builders group calculated the cost of their products to determine an affordable price by comparing it with others. (Researcher Journal)*

Persuasion Skills

Students' progress in Persuasion Skills was monitored. S10 and S7 disagreed on the product name. The findings are a direct result of the inquiry in this domain.

> *S10 and S7 competed for the product name. S10, like S7, dominated and forced him to agree to his name. (Researcher Journal)*

Creating a Communication Channel/Environment

The analysis focused on students' ability to establish a medium of exchange for measuring growth. Researchers found S17 inclined to communicate ideas to a broader audience and had already identified suitable channels for dissemination. S17's statement declares their capability in this area.

> *I will explain. I bought these items online. People will benefit from using this product. I plan to draw attention to myself by acting like a used car salesman. (S17)*

Since participants lacked cell phone access, the researcher created a Google Classroom class called "4-Entrepreneurs" for communication. Below is the data collected from this line of communication.

> *Students enjoyed interacting with the researcher and frequently used the app, as evidenced by comments in the Google Classroom. (Researcher Journal)*

Planning

S6 presented a comprehensive overview to all cohorts, detailing the materials planned for the Little Builders group's product design, as well as relevant applications and methods of use.

> *We installed streetlights and erected a single iron rod outside town, with a camera mounted to record the flood. The camera will be visible from anywhere in the city due to its widespread presence. A cable transmits information from the ground up to the mosques and lamps. (S6)*

Attitudes

Having a Trustworthy Character

The study examined students' growth in cultivating a dependable character. Adherence to obligations and self-assured conduct were significant factors contributing to reliability. The data is presented below.

> *S7's concern about missing a previous lesson demonstrates her responsibility. She never missed another lesson, and her family supported her. (Researcher Journal)*

Desire for Success

Students' development was observed within the context of the Desire for Success attitude. S16 effectively communicated with stakeholders to ensure the product's success. The interview results are presented below.

> *S16 from The Best Engineers of the World group explained that his designed system warns of floods and other natural events. He consulted his father's friends and AFAD members for ideas. (Researcher Journal)*

Change and Transformation

The researchers monitored students' receptiveness to change and ability to transform. S13 proposed altering his colleagues' designs to achieve the highest quality and practicality. Here is his comprehensive statement:

> *What if most people do not understand? What are your plans? This is not an option. An app could send a signal. What if this were a phone feature? Nobody might install the app. (S13)*

S6 incorporated design elements from S2 and S3 to create a novel product that caters to a broader audience at an affordable price. The statement is presented below in its appropriate context.

> *In the Small Builders group, member S6 created something new by fusing the concepts of two earlier products, S2 and S3. (Researcher Journal)*

One team member, S8, suggested that the Change and Transformation mindset framework allows for price modifications for specific products. S8's relevant statement is:

> *This is the most cost-effective option for powering it, and it can be done anywhere. A large battery pack could power it, depending on the price. There is likely at least one nearby. If the noise level is acceptable, take it one neighborhood at a time. We can adjust the price if it is not satisfactory.*

Flexibility

The researchers observed a significant improvement in students' ability to adapt to novel situations effectively. They worked with people outside their social circle, demonstrating flexibility and independence. The following statements are presented within this context.

> *Although he was part of the Best Engineers in the World team, S5 from the Small Builders team had no trouble expressing his ideas. (Researcher Journal)*

Participants in the focus group became more willing to participate in interviews. They managed to schedule interviews autonomously without the researcher's help. The conclusion follows.

> *Student members of the Engineer Stars group stated that they planned to continue working independently of the researcher. (Researcher Journal)*

Self-confidence

The students' progress was assessed based on their self-confidence levels. The findings are presented in the following sections. S7's self-assurance was evident in their presentation, as noted by S16. S16's perspective on S7 is elaborated on in the following discourse.

> *The seventh member of S7 has the most assurance. Your assurance and clear explanation impress me. (S16)*

S19 and S18, despite their lack of verbal communication, effectively collaborated to conceive a product, articulate its features to practitioners, and counter objections. These statements were uttered in this context.

> *Only S19 and S18 answered our questions. They claimed they planned to meet without the researcher, but when that failed, they brainstormed a product. Surprisingly, two students made such a breakthrough, given their silence throughout the research. (Researcher Journal)*

Determination to Work

The students' development was observed in relation to their Work Perseverance attitude. S13 and S11 have provided the following statements and observations regarding.

> *Teacher, I shared my study idea with my father, an engineer. We examined it, including the electrical demolition video. (Researcher Journal)*

S6 expressed a desire to learn about his friend's program and develop it. S6's commitment to employment is as follows. S11 and S12 were interviewed to gather information for their product presentations. S11 was enthusiastic about contributing to the presentation. The observation statement is provided below.

> *S11 prepared a new presentation for the meeting, which S11 and S12 attended. S14 will create the user guide and add it to the presentation. S11 wants more responsibility and realizes it. (Researcher Journal)*

The following presentation showcases the product designs in Figure 4 created by the team designated as S11:

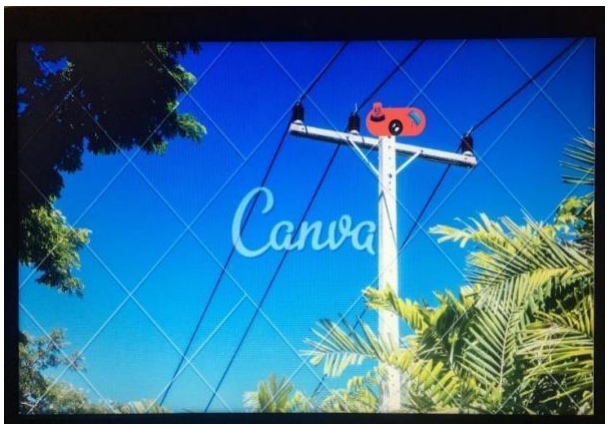

Figure 4. A slide from the Presentation of the Engineer Stars Group

It was discovered that S8 believed that he could surmount challenges by adopting a resolute work ethic.

Loving the work they do

The study examined students' development in relation to their attitude toward their chosen pursuits. The results are presented below. The students' anticipation and enthusiasm for

activity-based learning heightened their excitement and interest in the subject. Their statements suggested that students were motivated to work on their projects rather than attend their courses. However, since this was not feasible, they worked on their projects only during the designated time. The students' expressions of enthusiasm are presented as follows.

> *The students were excited about the study and insisted to the researcher, "Take us from all courses; let us work." (Researcher Journal)*

At the start of the online interview with the Engineer Stars group, only S14 participated. The remaining members joined the interview later. Here is the statement about their chosen occupation.

> *S14 said the other group members did not participate in the live lessons and doubted they would do so again. The students apologized for being late and joined the lesson. S14 suggested they have found the work enjoyable. (Researcher Journal)*

Students interviewed an electrical engineer for career development and a young entrepreneur. The observation statement is provided below.

> *After interviewing the entrepreneur and engineer, their interest and seriousness in the study increased. (Researcher Journal)*

S1, a member of the Small Builders group, found joy in his work and was pleased to share his knowledge with his peers.

Critical thinking

The analysis focused on students' cognitive development regarding their critical thinking skill. Students expressed positive and negative remarks during the design process. The findings are elaborated in the subsequent section.

> *Some of S3's friends liked the final product, but others (including S1, S4, and S6) pointed out flaws. (Researcher Journal)*

S7 proposed reinforcing electricity poles to enhance their structural integrity and reduce the risk of collapse. They also suggested developing a specialized product for this purpose. The following section presents the results of a comprehensive analysis in this field.

> *S7 suggested fortifying the poles from below, but S10 deemed it absurd. (Researcher Journal)*

The team from Small Builders developed a method to notify the public of a large-scale power outage, which they incorporated into their product. However, one acquaintance, S1, expressed strong disapproval of the plan. The findings are presented here.

> *S1 criticized the plan to cut power to homes while issuing warnings to the public through lights and visual cues. They argued it is illogical to further victimize the public by cutting electricity access. (Researcher Journal)*

The Engineer Stars group proposed a mobile app to alert the public about an impending flood. However, S13 argued that implementing this option was not practical for the residents. The details are in the next section.

> *Some users may not be able to download the app, so it would be more cost-effective and accessible if the feature were part of the phone's default configuration. (Researcher Journal)*

Upon the conclusion of their presentation, the Engineers Stars group was subjected to the subsequent critique from S17:

> *Teacher, I think it sounds false because of how much it costs. (S17)*

Coping skills/crisis management

The students' resilience in overcoming challenges has garnered attention. While the literature on entrepreneurship does not explicitly cover struggle and crisis management skills, these qualities are evident in the efforts of entrepreneurs. S16 designed a product to document and inform about various natural disasters, beyond floods. She presented her concept at the AFAD, receiving feedback that its implementation was unfeasible. S16 intends to develop an additional product related to the research, but prioritizes realizing this design. The outcomes of this capability are presented below:

> *AFAD members stated that it was impossible to produce the product due to specific issues, but S16 insisted that a screen could reflect natural events and take precautions. The student was upset but vowed to improve the product if he consulted others and found solutions. (Researcher Journal)*

On the presentation day, the Myth Team group failed to show the S10 video. S10 said there was a brief delay loading it. This statement fits this competency.

> *After figuring out why S10's presentation would not open, he could complete it. (Researcher Journal)*

Discussion

Knowledge

The concept of the invention is observed despite the absence of explicit references in Hisrich and Peters (1989) and OECD (2015). Nations must prioritize the development of successive cohorts deeply ingrained with this guiding principle to achieve equilibrium between production and consumption, thereby exerting a substantial influence on the future trajectory (TUSIAD, 2017). Uçak and Erdem (2020) emphasized the relationship between production and economic advancement, noting that nations achieve growth through heightened output. This viewpoint can be traced back to the Industrial Revolution. The marketing process is crucial for product growth and development. Entrepreneurial talents are indispensable. The study’s findings indicate that knowledge acquisition and development in production and growth can be attributed to STEM activities.

Successful entrepreneurs possess specific skills, including adequate capital, thorough feasibility studies, access to financial resources, constructive competition, and investing in profitable

areas. Etemand (2004) emphasized the importance of international orientation, global thinking, and business financing for entrepreneurs. Students demonstrated an understanding of environmental impacts and recycling practices, as well as market dynamics through price research, innovation fostering, and effective communication, as shown in their posters. They also showed familiarity with entrepreneurship. Previous research on primary school entrepreneurship education has focused on basic concepts, identification, and advertising strategies. Evidence suggests that students may be predisposed to certain entrepreneurial practices due to their participation in STEM activities.

Skill

The study found that students displayed behaviors and expressions within the Innovative and Creative skills domain. This skill is listed in various entrepreneurship skills tables, including those of Akyürek and Şahin (2013), Ethemand (2004), Hisrich and Peters (1989), and Morris (1998). TUSIAD (2017) emphasizes the importance of these skills, noting their increasing demand. Jacobs (1989) suggests that creativity can solve problems. The study observed that students demonstrated their innovative and creative skills, especially in the later stages of the intervention, which was likely due to the STEM activities. The inherent characteristics of STEM education enhance creativity, and engaging in STEM-based activities improves entrepreneurial skills.

Entrepreneurship requires the ability to focus on opportunities. For an entrepreneurial movement to thrive, individuals must acknowledge their limitations and see them as opportunities. Çetinkaya-Bozkurt and Alparslan (2013) defined an entrepreneur as someone who seizes opportunities, emphasizing the importance of this aptitude. Students were allowed to explore their skills and demonstrate their abilities in the research. Tekbıyık and Çakmakçı (2018) emphasized the importance of recognizing and developing students' skills by incorporating STEM applications. It is crucial to cultivate self-confidence in primary school students by providing opportunities for self-discovery and knowledge sharing. Students demonstrated a proactive approach to knowledge dissemination and a heightened ability to identify details in product design, transforming them into opportunities. This enables students to acquire and develop the aptitude to focus on prospects in E-STEM endeavors.

Studies identify cooperation as a skill, but communication skills are inconsistent (Akgündüz et al., 2015; TUSIAD, 2017; Uçak & Erdem, 2020). Effective communication is crucial for establishing and sustaining cooperation. Students with communication difficulties disengage from research due to ineffective collaboration. Effective communication is essential for group planning and decision-making. Jacobs (1989) found a comprehensive overlap among the aspects of skill teaching. Observing a student's expression reveals multiple skills. Cultivating effective communication, a key entrepreneurial competency, can be facilitated through STEM activities.

Çetinkaya Bozkurt and Alparslan (2013), Morris (1998) and TUSIAD (2017) lack management and leadership skills in their analyses. The report by TUSIAD (2017) suggests enhancing administrative practices in response to rapid technological advancements, increased information accessibility, and information overload. Uçak and Erdem (2020) argue that individuals should lead change within themselves. Jacobs (1989) suggests students can assume leadership roles in cooperative learning environments, especially in project-based studies.

Students demonstrated leadership qualities across various academic disciplines in multiple studies. Implementing activity-based studies with diverse courses and content develops students' self-assurance, highlights leadership abilities, and fosters entrepreneurship. STEM activities facilitate leadership skill development.

Risk-taking skills, though not part of 21st-century skills, are often discussed in entrepreneurial literature. Scholars (e.g., Ağca & Yumuşakipek, 2015; Yılmaz & Sünbül, 2009) define entrepreneurs as risk-takers. Hisrich and Peters (1989) emphasized the importance of risk-taking for students to gain new knowledge and face setbacks, while TUSIAD (2017) underscored the importance of risk-taking in STEM to promote innovation. In this study, students' risk-taking abilities were identified and found to improve over time.

Entrepreneurship skills include identifying and analyzing problems, generating viable solutions, and understanding students' cognitive processes. Problem-solving is a primary subcomponent of engineering skills, and integrating it into the curriculum is crucial for developing competent individuals. The Organization for Economic Cooperation and Development emphasizes the importance of engaging students in real-life problem-solving scenarios to foster entrepreneurial skills. Research indicates that students with enhanced problem-solving skills, a subset of entrepreneurial skills, tend to exhibit better performance in STEM activities that involve real-life problems. Collaboration between industry, educational institutions, and educators is essential for adequate STEM studies and addressing STEM-related challenges. STEM activities facilitate the development of collaborative working skills.

In the literature, tolerance for uncertainty is described as the ability to cope with situations where information is incomplete or unclear, rather than as having little uncertainty. Comprehensive explanations of this skill in relation to uncertainty were unavailable. Research findings suggest that students' recent acquisition of market sensitivity and inadequate planning contribute to the emergence of uncertainty. However, students effectively navigate and address these uncertainties. STEM activities enhance the skill to handle ambiguity and unpredictability effectively.

Çetinkaya Bozkurt and Alparslan (2013) and Hisrich and Peters (1989) include decision-making skills in their statements. Gencer et al. (2019) emphasize their importance in engineering abilities, while Uçak and Erdem (2020) highlight their commonality in technology skills. Research shows that students use decision-making skills during problem-solving and facilitate cooperation in collaborative tasks. Therefore, engaging in STEM activities is crucial for acquiring and enhancing decision-making skills.

The OECD's 2015 publication mentions planning skills, while the ISTE (2016) categorizes them as "Organizing Information," involving resource allocation and strategic information management. STEM activities aim to develop products, so students must plan and execute product creation consistently. Integrating a STEM product into society requires qualification to align with societal needs. Students must strategically organize each phase of conceptualization, design, and production for public consumption. Yurtseven's (2020) research suggests that primary school students can develop planning skills if supported explicitly. Ağca and Yumuşakipek (2015) argue that planning helps businesses maintain focus on objectives. Empirical evidence suggests that students who plan and execute projects consider the societal benefits. STEM activities enhance entrepreneurial planning skills.

Students' critical thinking skills were evident in their development of different perspectives throughout the design process, their ability to offer suggestions, and their willingness to express opposing views. Participants demonstrated the cognitive aspects of critical thinking by evaluating technical proposals based on both logical reasoning and social impacts. Critical thinking is a crucial 21st-century skill supporting STEM education. Yurtseven (2020) suggested engaging in activities and using training tools to acquire critical thinking skills. Empirical evidence shows a positive correlation between directing attention to potential avenues and critical thinking. Developing critical thinking involves continuous inquiry and reflection, enabling individuals to discern and seize opportunities. However, as Willingham (2007) argues, critical thinking is not a generic skill that can be taught in isolation; it is deeply tied to domain-specific knowledge and requires sustained practice to be effectively applied.

Ethemand (2004) emphasized the ability to create communication channels. The International Society for Technology in Education's (ISTE, 2016) student standards, titled Creative Communicator, emphasize choosing suitable communication channels and seamlessly incorporating products into appropriate platforms. Students need appropriate communication channels for designing and presenting products in STEM and entrepreneurship activities online. Research has found that engaging in STEM activities can enhance essential skills in communication technologies, which are crucial in contemporary society.

The concept of tackle is evident in Tarhan’s (2019a) study. Students feel despair when creating, finalizing, valuing, and defending products compared to others. They need skills to manage this process effectively. Struggle skills include persistence in decision-making, emotional intelligence, and problem-solving. Akyürek and Şahin (2013) and Ethemand (2004) identified and included these three skills in their list of entrepreneurship skills.

Attitude

Upon careful observation during the study process, it became apparent that behaviors and expressions associated with a dependable character closely resemble those of a responsible individual. While entrepreneurship is not explicitly mentioned in the literature, it is plausible that entrepreneurship encompasses responsible and reliable attitudes. Two conceptual frameworks were used to examine this topic. Several studies (Ercan & Sünbül, 2009; Gencer et al., 2019; Jacobs, 1989; Uçak & Erdem, 2020; Uştu, 2019) focused on responsibility but neglected reliability. Jacobs (1989) argued that children develop responsibility and independence as they fulfil their obligations. The study’s findings supported this assertion. S11 earned the trust of his peers and educators through conscientious duty. Analysis revealed that STEM activities foster a dependable character.

The absence of the desire for success was observed in Morris’s (1998) work and the OECD’s (2015) findings. Ercan and Sünbül (2009) discussed the importance of taking risks for success. Evaluating this disposition alone is imprudent. Individuals aspire to professional success, but circumstances play a significant role. Success following a risk-taking endeavor requires perseverance and persistence despite setbacks and failures. It also involves emotional challenges. The research found that students experienced various emotions and situations during the 9-week study, but their primary goal was optimal outcomes for their presentation. Based on these rationales, STEM activities can cultivate students' inclination towards achieving success.

The change and transformation aspect of attitude is not included in Ethemand (2004) or the OECD (2015). Morris (1998) found that this attitude was the most effective in implementing initiatives. Technological advancements require significant skill changes, as indicated by TÜSİAD (2017) and Uçak and Erdem (2020). Yılmaz and Sünbül (2009) found that recognizing change leads to identifying opportunities. Due to the COVID-19 pandemic, the planned in-person research was initially adapted to an online action research methodology. The research found that students adapted to the change and enhanced their attitude.

The literature on entrepreneurial skills does not emphasize flexibility. Uştu (2019) observed this attitude in collaborative work, where diverse perspectives are accepted. Adopting a flexible mindset and adaptive behavior is crucial in a collaborative professional setting. Uçak and Erdem (2020) found that flexible behavior depends on adapting to innovations. Students showed a disposition towards adaptability and cognitive abilities in both scenarios. Based on the research, engaging in STEM activities facilitates the development of a flexible mindset.

Self-confidence, defined as a key entrepreneurial trait by Yılmaz and Sünbül (2009) and a blend of self-confidence and respect by Ethemand (2004), is essential for developing students' entrepreneurial characteristics, as evidenced by increased self-confidence and positive attitudes toward STEM activities (Yurtseven & Ergün, 2018). Perseverance, identified as a critical entrepreneurial attribute (Hisrich & Peters, 1989; Yurtseven & Ergün, 2018; Yurtseven, 2020), is demonstrated by students' determination and commitment in STEM participation. While Hisrich & Peters (1989) discussed job satisfaction, Yılmaz and Sünbül (2009) emphasized performing duties with ardor and resoluteness. Students' enjoyment of academic tasks and independent interviews suggests a clear link between positive attitudes toward STEM activities and the development of entrepreneurial skills such as self-confidence, perseverance, and work satisfaction.

Implications

While we acknowledge the need for caution regarding the complexity of entrepreneurial practices at the primary level, our findings suggest a critical distinction between skill internalization and explicit demonstration. We argue that while the students may not have fully presented these skills in a conventional or professional manner, we frame these results as exploratory evidence that cognitive acquisition of these skills often precedes the ability to fully articulate or showcase them. Recognizing this developmental trajectory allows us to appreciate the structural impact of the applied pedagogical strategies. STEM-based action research interventions in primary school classrooms are an effective strategy for fostering foundational entrepreneurial skills early in students' development. Specifically, the success of utilizing authentic contextually relevant scenarios indicates that educators should incorporate place-based cases to enhance student engagement and the practical application of skills such as problem-solving and risk-taking. It is also advisable that engineers engage in collaborative research to thoroughly explore the subject matter. Ultimately, these findings advocate for a curriculum shift that merges technical STEM literacy with entrepreneurial competencies to better equip young learners for future economic and innovative demands.

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