Journal of Innovations in Science, Mathematics and Computing Education
2025, 1(1), pp. 57-70 Research Article

Cultivating Career Interests and STEM Attitudes in High School Students: The Role of Smart Agriculture Applications

Figen Eğin[a*], Aytuğ Onan[b], Nilüfer Atman Uslu[c], Gökben Yılmaz[d], Emin Borandağ[e]
[a]PhD Candidate, İzmir Katip Çelebi University, https://orcid.org/0000-0003-4865-5789
[*]figenkaya@gmail.com
[b] Professor, İzmir Katip Çelebi University, https://orcid.org/0000-0002-9434-5880
[c] Assoc. Prof. Dokuz Eylül University, https://orcid.org/0000-0003-2322-4210
[d] Teacher, Ministry of Education, https://orcid.org/0009-0007-4843-0340
[e] Assoc. Prof., Manisa Celal Bayar University, https://orcid.org/0000-0001-5553-2707

Submission: 03.03.2025 Acceptance:28.05.2025

Abstract

Coding education is becoming widespread in all countries, and students are expected to be able to integrate technology with life problems by creating innovative and creative designs. The theme or unstructured problem situation to be presented to students to produce solutions with technology should be authentic and current and point to a problem they encounter. One of the most important problems we have faced recently is global warming and the climate crisis. The climate crisis requires countries to determine new policies and innovative approaches, especially for agriculture field. Sustainable agriculture stands out for a sustainable future, and the key to sustainable agriculture is smart agriculture with today's data. This study evaluates project results. The project was aimed at the participants to gain awareness about agricultural activities in their region by learning smart agriculture. They were trained through fun and practical activities which show them the importance of studies conducted in this field. The project goal was raising the participants' recognition of the need to use technology for solving the problems they encounter in their environment. This study presents evaluations regarding a project organized within the scope of TUBITAK 4004. Participants consist of 30 students in the 10th grade of state high schools. According to the study's quantitative findings, although there was a significant increase in students' overall interest in engineering and STEM, the change in their interest in the fields of science and technology was not statistically significant. An examination of the qualitative findings revealed that students found the educational experience both enjoyable and informative; however, they indicated that improvements were needed in activity durations and time management. These results will guide the design and planning of similar project activities to be carried out in the future.
Keywords: STEM education, robotics, coding, smart agriculture, career interest

Özet

Kodlama öğretimi tüm ülkelerde yaygınlaşmakta, öğrencilerden yenilikçi ve yaratıcı tasarımlar ortaya koyarak teknolojiyi yaşamla ilişkilendirebilmeleri beklenmektedir. Öğrencilere teknoloji ile çözüm üretmesi için sunulacak temanın ya da yapılandırılmamış problem durumunun otantik, güncel ve hayatında karşılaştığı bir soruna işaret etmesi gerekmektedir. Son dönemde yüz yüze olduğumuz en önemli problemlerden biri küresel ısınma ve iklim krizi olarak görülmektedir. İklim krizi, özellikle tarımda ülkelerin yeni politikalar belirlemesini ve yenilikçi yaklaşımları zorunlu hale getirmektedir. Sürdürülebilir bir gelecek için sürdürülebilir tarım öne çıkmaktadır ve sürdürülebilir tarımın anahtarı ise bugünkü veriler ile akıllı tarımdır.

Bu araştırmada, TÜBİTAK 4004 kapsamında düzenlenen ve uygulamalı etkinliklerle katılımcıların akıllı tarım konusunda farkındalık kazanmalarının amaçlandığı bir proje çalışmasına ilişkin değerlendirmeler sunulmuştur. Proje çalışmasında, katılımcılar teknolojiyi çevrelerinde karşılaştıkları problemlerin çözümünde kullanma bilincinin kazandırılması hedeflenmiştir. Katılımcılar devlete bağlı liselerde 10. sınıfa geçen 30 öğrenciden oluşmaktadır. Çalışmanın nicel bulgularına göre, öğrencilerin mühendislik ve STEM genel ilgisinde anlamlı bir artış olurken, fen ve teknoloji alanlarındaki ilgi değişiminin istatistiksel olarak anlamlı bulunmamıştır. Nitel bulgular incelendiğinde ise öğrencilerin eğitimi eğlenceli ve öğretici bulduğunu, ancak etkinlik süreleri ve zaman yönetimi konusunda iyileştirmeler yapılması gerektiğini ortaya çıkmıştır. Elde edilen bu sonuçların, gelecekte yapılacak benzer proje etkinliklerinin tasarımında ve planlanmasında yol gösterici olacağı düşünülmektedir.
Anahtar kelimeler: STEM eğitimi, robotik, kodlama, akıllı tarım, kariyer ilgisi

INTRODUCTION

Technological advancements have led to the emergence of 21st-century skills, emphasizing the need for students to adapt to unpredictable future careers. One of the 21st-century skills, computational thinking, involves students breaking the problems they face into small pieces and reaching a solution step by step (Temel & Mumcu, 2024). In this respect, computational thinking skills are considered within the scope of computer science, and they can be improved through coding instruction since they involve a similar approach. Due to economic concerns, many projects have started to be carried out worldwide to teach coding to students, and countries have added coding to their curricula one after another (Sayın & Seferoğlu, 2016). Another point that is as important as providing chances for students to gain these skills also is increasing their motivation to use technology to solve these problems in today's world, where we face many environmental and social problems. Therefore, the mission of educational curricula to raise individuals who know coding and can use technology for their purposes is not enough. It is necessary to raise individuals with high awareness of the use of technology to solve environmental and social issues.

One of the areas where technology is used as a solution to today's problems is "smart agriculture" implementations. Smart agricultural practices enable more conscious and judicious practices with the help of technology. In this way, the environment and soil are protected, and yields are increased. Increased harvest can help prevent the current food crisis. In this respect, smart agricultural practices also serve the "Zero Hunger" theme among the United Nations Sustainable Development Goals (İşler, 2023). This theme includes the sub-target of technology development to increase agricultural production capacity. As a result, raising awareness among young people on "Smart Agriculture" practices can be considered very important. Raising awareness in this field can be achieved in the school environment and out-of-school learning environments. While out-of-school learning environments contribute to students' consolidation and adaptation of the knowledge they have acquired to their daily lives, they also play an important role in determining their future career goals (Gossen & Ivey, 2023). The "TUBITAK 4004 Nature Education and Science Schools Support Program", which appears as an out-of-school application, aims to bring scientific knowledge together with society by encouraging science camps. These projects, supported by interactive and visual methods, aim to improve participants' scientific thinking skills, ensure their active participation in learning, and raise scientific insight. Within the program's scope, science schools and nature-based activities are organized in various disciplines such as agriculture, ecology, environmental problems, science, history, and geography (Karakoç Topal, 2022). These projects enhance students' knowledge of smart agriculture beyond the classroom. In this context, this study aims to assess the results of the "Designing Agriculture of the Future with Smart Technologies" project carried out with the support of the TÜBİTAK 4004 Nature Education and Science Schools Support Program.

Related Research

With the ubiquitous accessibility of Information and Communication Technologies (ICTs), a different social structure is observed in all areas of life, including work, communication, and education, as well as accessing, producing, and sharing information. In this context, in recent years, there has been an increase in formal and informal education activities for students to create solutions to daily problems with technology, and educational robotics has emerged as one of the technologies used for this purpose. Educational robotics provides an environment where they can generate hypotheses about how mechatronic parts work and conduct experiments to verify their assumptions (Chang, Lee, Chao, Wang, & Chen, 2010). Also, educational robotics activities support problem solving processes (Taylor & Baek, 2018). They can be considered an innovative learning tool for developing higher-order thinking skills such as critical and computational thinking (Atmatzidou, Demetriadis, & Nika, 2018). Thanks to the widespread use of educational robotics, research, and practice have suggested various ways to use it in learning and teaching. These ways are discussed under three headings and explained below respectively: (a) basic robotics programming concepts, (b) structured problems, and (c) unstructured problem situations (Atman Uslu et al., 2023).

Basic robotics programming concepts: Key elements include the recognition of robots and their capabilities, a thorough understanding of their fundamental functions, the intricacies of circuit construction, the effective application of sensors, and the implementation of control structures that enable programming logic (Ayar, 2015; Castro et al., 2018; Mac Iver & Mac Iver, 2019).

Structured problems: The literature reveals that students often encounter structured robotics problems characterized by clearly delineated rules and specified operational requirements (Atmatzidou et al., 2018; Küçük & Şişman, 2017). In these scenarios, students have the opportunity to independently reconfigure pre-designed robots or tackle specific challenges, such as transporting a predetermined weight over a specified distance

Unstructured problem situations: Research has centered on the creative aspect of robotics education, focusing on students as they develop robotic projects that are based on designated themes (Gomoll et al., 2018; Gomoll et al., 2017; Taylor & Baek, 2018). This process encourages innovation and critical thinking, allowing students to explore their own ideas (Gomoll et al., 2018; Taylor & Baek, 2018). This is evident in the approach that has the potential to support students' creativity, the use of technology for production purposes, and the enrichment of interdisciplinary learning rather than being discipline-oriented. Among these learning and teaching methods, robotic project development through unstructured problem situations stands out as a strong example. In this way, it can be ensured that students follow the stages of the Engineering Design Cycle in their robotic project development.

The stages of the engineering design cycle (Gomoll et al., 2016):

- Ask a question: At this stage, the problem is defined, and how a robot can be built with the affordable materials provided is discussed.
- Imagine: Brainstorm possible solutions. The problem is examined from various aspects.
- Collect Data: Information is collected to identify the capabilities and constraints of the problem and context.
- Develop and Test Solutions: Configure, program, and test the robot in an iterative process.
- Improve: Make revisions to the design by receiving feedback.

For students to develop a robotics project by following the engineering design stages, the given theme or unstructured problem situation should be authentic and current and point to a problem encountered in their lives. Within this framework, the necessity of implementing sustainable agricultural practices during the climate crisis emerges as a local, regional, national, and global problem. Agriculture is one of the areas most affected by climate change (Bayraç and Doğan; 2016). Decreased agricultural crops due to climate change may lead to a food crisis (Akalın, 2014). There is a need to increase agricultural productivity and introduce sustainable agricultural policies. At this point, promoting sustainable agriculture will raise product performance and ensure the establishment of a more environmentally sensitive system (Khor, 2009). The concept of sustainability includes many goals, from planning sustainable cities to sustainable livelihoods, from sustainable agriculture to sustainable fisheries (Robert, Parris, and Leiserowitz, 2005). The key to sustainable agriculture is smart agriculture (Walter, Finger, Huber, & Buchmann; 2017). When smart agriculture applications are examined,

- Disease detection using artificial intelligence methods (Acar, 2012),
- Providing irrigation control with moisture sensors (Özden, 2013),
- Precision fertilization using UAVs (Arikan, 2019),
- Investigation of plant growth using UAV (Aslan, 2019) and
- Studies have been carried out on the development of smart systems in greenhouses using Arduino and its components (Demiryürek, 2019).

The rate of smart agriculture and innovation in Turkey is very low, and agricultural incomes and productivity can be improved by adopting innovative technologies in agriculture (Yener, 2019). Considering Turkey's agricultural potential, directing young people towards smart agriculture initiatives, expanding smart agriculture practices, and increasing awareness in this field will provide added value to the national economy and facilitate access to cheap and quality food in the long run.

METHOD

Research Design

The study was conducted in a mixed design in which quantitative and qualitative methods were used together. Quantitative data were collected through pre-test and post-test using the scales specified "Data Collection

Tools." and was designed as quasi-experimental and all participants took part in the study as the experimental group. Qualitative data were collected during the activity week and at the end of the activity. Figure 3 shows the stages of the research.

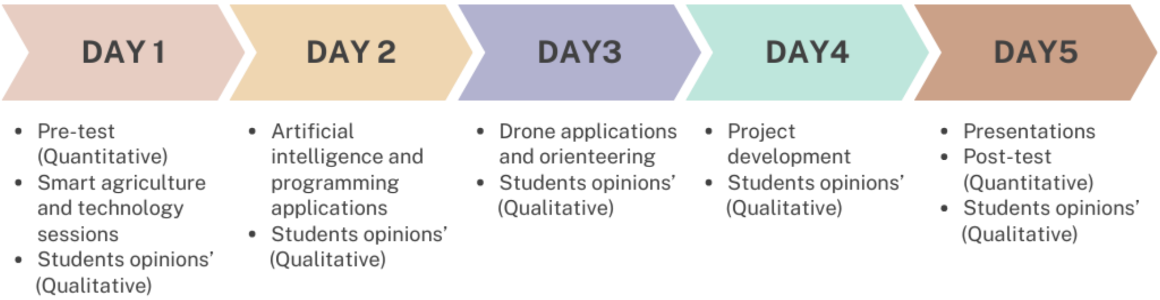

Figure 3. *Stages of the research*

"Designing Future Agriculture with Smart Technologies" TUBITAK 4004 Project

The project aimed to increase the robotic coding and 3D design skills of 9th-grade students through practical activities. It also focused on creating technological designs for smart agriculture applications and raising students' awareness of using technology to solve social problems.

In this context, the students received hands-on 3D design and robotic coding training, and they examined the work done in the area of smart agriculture and received information from experts. The students developed prototypes for smart agriculture applications to solve the problems they identified through field trips. While completing their projects, they practiced robotic coding, used 3D drawing programs to create the necessary designs for their projects, and printed them on 3D printers. Thus, theoretical knowledge is transformed into practice.

The activities were designed to contribute to the participants' coding and robotic coding, 3D design, and engineering design skills. In addition, it was expected to increase their level of interest and awareness about agricultural activities and smart agriculture practices in their region. The project aims for the participants to gain self-confidence by tasting the feeling of being beneficial to society with the solutions they will bring to the problems in their immediate environment. Plus, the participants were encouraged to enhance their perception for using technology to solve real-life problems with an interdisciplinary approach. Participants prepared posters to promote and exhibit the smart agriculture projects they developed.

Figure 4. *Students' project exhibition*

Participants

Participants were selected from 9th to 10th-grade students in public high schools in Manisa province. 9th-grade students were selected as participants based on the match between the curriculum of the Computer Science course taught in 9th grade and the project objectives. Although it was tried to provide students with acquisitions related to robotic coding within the scope of Course 2 of the Computer Science course, it was determined from interviews with information technology teachers working in high schools that the schools were insufficient regarding technical equipment.

During the selection of participants, purposive sampling was used in the selection of participants and priority was given to students with high academic success and socio-economically disadvantaged, academically successful students who are interested in the field of robotic coding. The number of participants was determined to be 30 students, half girls and half boys, from different schools, considering the activities' efficiency and applicability. To increase student interaction and communication, and to create a collaborative working environment, six groups of five students were formed. A guide was assigned to each group to support and oversee their work. Written consent was obtained from parents for all participants.

Data Collection Tools

This project aims for the participants to develop projects in which they produce solutions with innovative technologies for sustainable agriculture problems that constitute a local, regional, national, and global problem situation, work collaboratively in the process, and enrich their interest and understanding of science, mathematics, technology, and engineering fields. In this respect, process-oriented evaluation approaches were used instead of classical summative evaluation tools that measure course content knowledge in evaluating the participants' projects. Indeed, the MoNE (2016) STEM Education report emphasizes that measurement tools should be developed to see and measure the student's mental process in questioning, researching, producing, and inventing activities.

A diary, observation, poster, concept map, checklist, rubric, self-assessment, group assessment, and peer assessment can be used in this context (Odabaşı, 2018). This project utilized participant diaries, rubrics, group assessments, and peer assessments to evaluate the participants' work. In addition to this, since this project aimed to increase young people's interest in this field, increase their motivation to produce technology, and direct them to the production of innovative agricultural technologies in the future, the "Career Interest Scale for STEM Fields" and "Motivation Scale for STEM Fields" were applied to the participants as pre-test and post-test.

Participants were asked to keep diaries electronically at the end of each activity day. In filling out the diaries, participants were asked about the noteworthy learning outcomes of the activity day, which topics and concepts they had difficulties to learn, and what they did to overcome these problems.

Career Interest Scale for STEM Fields and Motivation Scale for STEM Fields

These two scales were developed by Kızılay (2018) for high school students within the scope of his doctoral dissertation studies. The Career Interest Scale for STEM Fields and the Motivation Scale for STEM Fields were developed by Kızılay (2018) for high school students. The Career Interest Scale consists of three factors: 'Self-efficacy' (7 items, α = .92), 'Outcome Expectation' (4 items, α = .86), and 'Interest' (9 items, α = .95), with an overall reliability coefficient of α = .96. Similarly, the Motivation Scale includes four factors: 'Confidence' (6 items, α = .95), 'Relationship' (5 items, α = .94), 'Attention' (6 items, α = .93), and 'Satisfaction' (5 items, α = .91), with an overall reliability coefficient of α = .97. These values indicate high internal consistency and reliability (Sönmez & Alacapınar, 2016; Seçer, 2013).

ETHICAL STATEMENT

This study adheres to ethical principles for research involving human participants. Data were collected as part of a standard course activity, and participants were informed in advance that their answers would dwell nameless and be utilized solely for academic purposes. No personally identifiable information was obtained, and participation was entirely voluntary. The study did not include interventions and risks.

FINDINGS

Quantitative Findings

This study compared pre-test and post-test scores to evaluate students' attitudes towards STEM and its sub-dimensions. Table 1 shows dependent sample t-test results.

Table 1: Dependent sample t-test findings regarding students' pre-test and post-test scores of STEM attitudes and its sub-dimensions

		N	Mean	SS	sd	t	p
Science	Pre-test	30	4.09	0.782	29	-0.410	0.684
	Final test		4.00	1.283			
Technology	Pre-test	30	4.51	0.518	29	0.408	0.687
	Final test		4.54	0.473			
Engineering	Pre-test	30	3.98	0.797	29	2.938	0.006
	Final test		4.31	0.631			
Mathematics	Pre-test	30	3.63	0.732	29	1.476	0.151
	Final test		3.77	0.843			
STEM	Pre-test	30	4.05	0.431	29	3.382	0.002
	Final test		4.23	0.498			

*: Significant difference at $p < 0.05$

Table 1 shows that there was no statistically significant difference between the pre-test and post-test scores in the sub-dimensions of Science ($t(29) = -0.410$, $p = 0.684$), Technology ($t(29) = 0.408$, $p = 0.687$) and Mathematics ($t(29) = 1.476$, $p = 0.151$). However, a significant increase was observed in Engineering ($t(29) = 2.938$, $p = 0.006$) and overall STEM scores ($t(29) = 3.382$, $p = 0.002$). These results show that the project activities had a positive effect, especially on engineering and general STEM perception. The fact that no significant difference was observed in the STEM sub-dimensions of Science and Technology indicates that different teaching strategies may be needed in these areas.

The results of the Career Interest Scale pre-test and post-test scores dependent on the sample t-test findings show that the training was generally effective in increasing students' career interest in STEM fields. While a significant increase was observed in Engineering (p = 0.012), Mathematics (p = 0.022) and general STEM interest (p = 0.009), no statistically significant change was found in Science (p = 0.078) and Technology (p = 0.293). Training was more effective in increasing students' career interests, especially in applied fields such as engineering and mathematics. However, no significant change was observed due to the initially high interest in Science and Technology. Results show that the training process positively affected participants' STEM career orientations. Whereas the increase in interest in some areas was not statistically significant. Table 2 shows the results.

Table 2: Dependent sample t-test findings regarding the pre-test and post-test scores of students' STEM Career Interest sub-dimensions

		N	Mean	SS	sd	t	p
Science	Pre-test	30	3.95	0.711	29	-1.828	0.078
	Final test		4.13	0.861			
Technology	Pre-test	30	4.44	0.361	29	-1.070	0.293
	Final test		4.53	0.467			
Engineering	Pre-test	30	3.92	0.707	29	-2.665	0.012
	Final test		4.20	0.638			
Mathematics	Pre-test	30	3.50	0.869	29	-2.416	0.022
	Final test		3.76	0.857			
STEM	Pre-test	30	3.95	0.444	29	-2.815	0.009
	Final test		4.16	0.560			

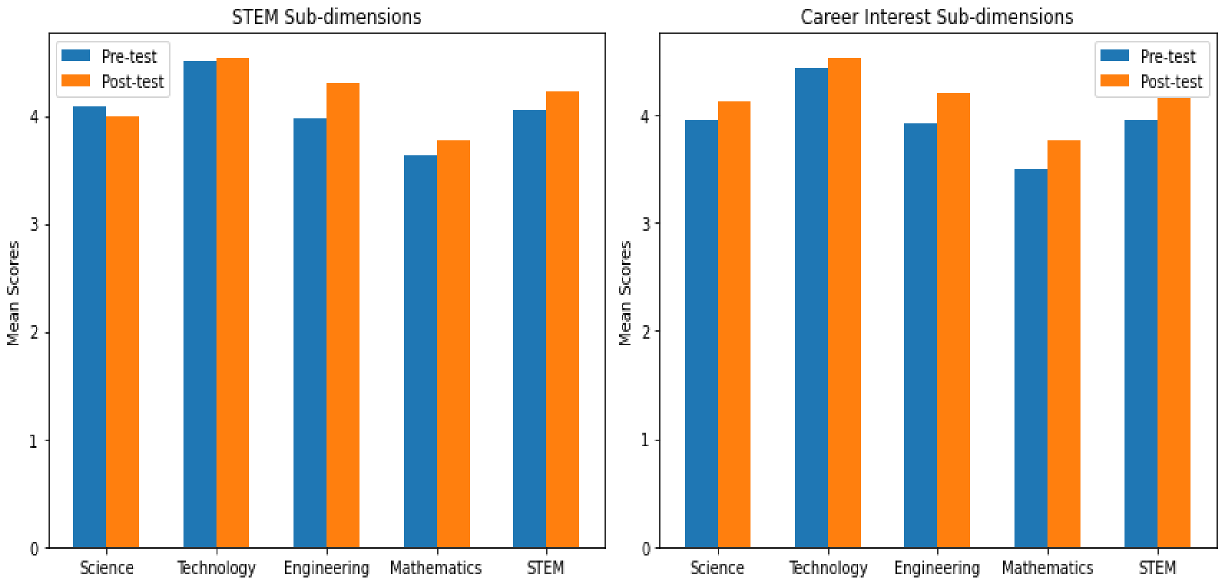

Figure 5. *STEM Career Interest Pre-test vs. Post-test Scores*

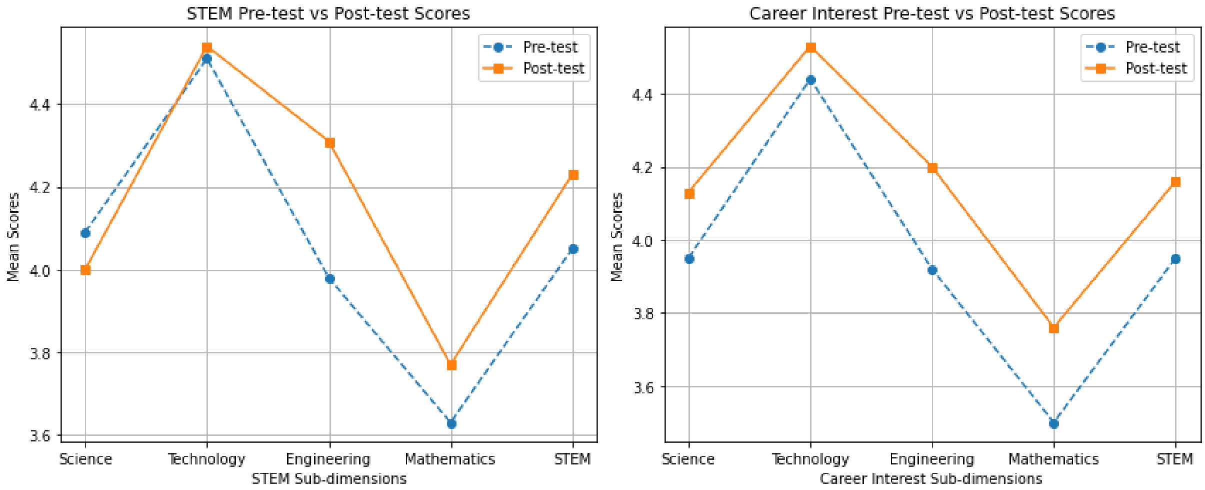

Figure 6. *STEM Career Interest Pre-test vs. Post-test Scores*

Qualitative Findings

The participants wrote reflections after the completion of each activities for 5 days. The participant diaries collected in this manner were analyzed through content analysis. Qualitative data were analyzed using inductive thematic analysis. Two researchers coded independently, resolving discrepancies through discussion. Accordingly, the themes were categorized under "achievements" and "opinions and suggestions regarding education."

Learning outcomes

Opinions on achievements were collected under "Smart Technologies and Agriculture, Technological Knowledge, Artificial Intelligence and Programming, UAV Technologies, Arduino and Electronic Projects." The students stated that the training was fun, instructive, and developmental. The participants indicated that they were pleased to learn new information with the combination of technology and agriculture and emphasized that such training should be organized more frequently. Some students suggested better planning lesson times, organizing activities in a way that allows everyone to participate in, and allocating more materials and time for projects. Overall, the participants were satisfied with the training process.

Table 3. Sub-themes collected under the main theme of gains and examples of student comments

Theme	Content
Smart Technologies and agriculture	"In the training I received today, I learned about the innovations created by the combination of agriculture and technology and the smart agricultural technology that will be present in our lives no matter what profession I will do in the future, how a quality olive oil is and how it should be, smart devices used in agriculture, and how agriculture can actually develop with technology."
	"I understood again how valuable technology is today. I learned that smart agricultural machines will make agriculture much easier. I learned how the quality of olive oil should be. I also clarified the purpose of this program and what it will bring me today. It was an intense day and I honestly think that the me of yesterday and the me of today are different people."
	"I learned about the contribution of smart agriculture to the economy, its importance for the future and its activities. I also learned how to grow the right olives."
	"I think that mobile applications and devices are useful for obtaining more efficient products in agriculture. If such applications are increased, we can go further in agriculture as a country."

Theme	Content
Technological Knowledge	"We saw technological methods and new technological products related to smart agriculture. We tasted olive oil and enumerated various properties of the oil. I realized how useful and necessary the use of technological methods and products in agriculture is." "With smart agriculture, we learned how to use machines and automation to grow crops more effectively and efficiently in the present and in the future. For example, that yields can be improved by not giving a plant more than its daily optimum water requirement, etc." "General information about the situation, problems and technologies used in agriculture and agriculture globally and especially in our country. I also got detailed information about olive and olive oil, which is an important agricultural product of our region." "Today, we examined 4 devices to increase efficiency in agriculture and we learned how important these devices are for farmers, first of all, thanks to these devices, water and fertilizer will be given at the right time and at less and more convenient times. Then we saw where smart agriculture is, we watched videos of devices that can hoe themselves and we saw that spraying is done very quickly with the help of special drones. These are all very costly tools, but if a cooperative is formed and farmers are open to innovations, they can of course get more efficiency with these technologies. And finally, we learned how olive oil is made, what stages it goes through and how to store it better."
Artificial Intelligence and Programming	"I learned who contributed to artificial intelligence and how it emerged, as well as its sub-branches. I saw how to make programs and coding and I did 3D design." "We learned new information about programming and artificial intelligence and made applications related to coding. The benefits for me helped me understand the logic of the programming language." "I learned about artificial intelligence from the beginning and in a comprehensive way, I learned about the AppInventor mobile application development platform and gained basic knowledge about it, I met Fractal Drawing and had the opportunity to exhibit a Fractal Drawing that was completely fed by my creativity with the MBlock platform, I learned to use the Tinkercad 3D design platform at a basic level and designed a small sketch fed by my imagination." "I learned about the history of AI, I learned new information about AI, and I learned some new types of coding." "I learned a lot of things such as 3D software, creating applications, and writing code with fun."
UAV Technologies	"I got a lot of information about the drone and I learned about the ruins of Sard, what happened there, who passed through, its history, and in doing so I saw the strength of the grouping." "I saw UAV-supported techno-farming practices, examined the parts of a drone and learned how they are assembled, and learned about the ruins of Sard." "In addition to the structure of drones and how they work at a basic level, I gained knowledge about UAVs and their use scenarios in smart agriculture thanks to the flying experience, I learned about the history of the region and its structures during the activities in the ruins of Sard, I tested my knowledge with the orienteering activity and participated in a fun competition with my friends."
Arduino and Electronic Projects	"We learned Arduino programming. We learned why Arduino is used and how it is programmed." "Today I learned what Arduino is and how to use it, and I also better understood how to work on a project as a group or individually."

Opinions on the Activities

The students found the training fun, productive, and instructive; they especially enjoyed the hands-on activities. However, they offered some suggestions such as better planning of activity durations, better time management, and making the materials available for everyone to use. They also stated that break times should be organized, the travel process should be made more efficient, and some topics should be explained more straightforwardly and in detail. By and large, the students emphasized that such trainings should be organized more frequently and stated that the training was informative and inspiring.

Table 4. Student views on the sub-themes and themes collected under the main theme of opinions on education

Theme	Content
Training Duration and Time Management	"Each of the trainings was individually labor-intensive and valuable. First of all, I must say that I am very satisfied. I just felt tired at the end of the day because it was back to back. Maybe if the break times are shortened and the breaks are increased, it may be better in terms of personal needs, especially in long trainings."
	"It was good but the duration could have been better adjusted because I used the drone but there were people who didn't."
	"I think the trainings I attended today were both fun and educational. But there was not enough time to fly the drone and not everyone who wanted to could do it. Time should be used faster and more efficiently and everyone should be allowed to try."
	"It was good. Could have left earlier."
Materials and Outputs	"For example, we would be happy to be given the design we made with a 3D printer."
Teaching Method	"More detailed and simple explanation in plain language." (Suggestions for better training)
Overall Satisfaction and Appreciation	"When I say that every day cannot be better than the day before, every day is another surprise, another innovation. I have never taken part in such a training before, but I would like to take part in such trainings and projects more often. I would like to thank all the people who contributed to this project. I am grateful to you for bringing us together in such a project."
	"I had fun while learning in the training I attended today. It was an enjoyable and pleasant experience for me. I also think that such trainings and projects should be more frequent."
	"It is a very nice project and I think we received a good education."
	"The moment of our presentation was good. Our teachers were very supportive."

RESULTS AND DISCUSSIONS

Based on the qualitative data collected, the activities provided an environment of experience for the participants regarding using and integrating technology in the agricultural field. The participants gained knowledge of smart agricultural applications, mobile applications, olive oil production and interpreted this information by conducting field observations. According to experiential learning theory, this method is more effective than lecture-based approaches in understanding materials (Kolbe, 1984). Participants also gained awareness about the benefits of smart agriculture on the effective use of resources. The STEM-based activities implemented in the project gave students an understanding of the use of technology in agriculture. In addition, product-oriented activities enabled the participants to produce concrete outputs. This approach may have positive effects on computational thinking skills. Indeed, product-based learning is also used in programming education (Araujo, 2024). During the activity week, participants designed products with different software development tools. In particular, the fact that the participants learned the structure of the UAV, examined its parts, and had a flight experience can be evaluated within the framework of experiential learning theory.

The use of UAVs is important in terms of acquiring technical skills and providing an understanding of how technology has a facilitating effect in the agricultural field. Besides, the orienteering activity, which was designed to provide an understanding of the history of the land, is an important example of gamified learning. Gamification is a method that increases motivation in education and involves students more in learning (Güneş, Balkışlı & Özçınar, 2024). The hands-on activities facilitated experiential learning, fostering new knowledge creation (Anjum, 2025). In the last stage, as a closing activity, projects created by participants for the exhibition as a group work provided a collaborative learning environment for the students. While designing electronic projects, the participants experienced the engineering design process, which covers problem definition, solution generation, testing, and development. This process can be considered to have a positive impact on students' problem-solving skills. The fact that the participants gave positive feedback about the training program shows that the activities included elements that increase motivation. The results show that the activities positively affected career interest in STEM. However, the notion that the increase in interest in some areas is not statistically significant can be attributed to the short implementation period. Conducting the study with a larger sample group may help to make the results clearer. Moreover, the absence of a control group in the study prevents causal inference. Therefore, experimental designs that include a control group are important for future studies.

As a result, this study examined the 5-day activities implemented within the scope of the project titled "I Design the Agriculture of the Future with Smart Technologies" and the effects of this process on students' career interests and motivation towards the STEM field. With five days of hands-on activities, participants worked on smart agricultural technologies, artificial intelligence, programming, drone systems, and Arduino-based electronic projects. The study's quantitative findings showed a significant positive difference in students' STEM career interests, especially in engineering and general STEM perception. However, the high initial interest in science and technology may have led to the lack of a statistically significant difference in these areas. Qualitative findings revealed that the participants found the training fun and instructive; whereas, there were suggestions such as better planning of activity durations and simplification of some topics. Since random selection was not applied in the selection of participants, selection bias may have occurred and this should be taken into account when evaluating the results. The findings provide insights for developing future STEM-based smart agriculture training programs. It has become evident that time management needs to be significantly improved in the planning of future activities. Such projects will elevate awareness among students on smart agriculture and using technology to solve problems of society and help them to plan their future careers in these fields. Integrating smart agricultural practices into STEM education curricula will have important effects. Improving students' recognition of sustainable agricultural practices is one of them. In this context, when determining educational policies, it will be beneficial to integrate smart agricultural topics such as Internet of Things (IoT)-based agricultural monitoring systems and artificial intelligence-supported decision mechanisms into STEM courses. Furthermore, encouraging extracurricular programs, research projects, and industrial collaborations in the field of smart agriculture will enable students not only to acquire theoretical knowledge but also to use their skills in the STEM field to produce solutions for real-world problems.

Acknowledgments

This study includes the evaluation results of the project titled "TÜBİTAK 4004 Akıllı Teknolojilerle Geleceğin Tarımını Tasarlıyorum (I Design the Future of Agriculture with Smart Technologies)". This project was supported within the scope of TÜBİTAK 4004 Nature Education and Science Schools Support Program. We remember with respect and gratitude our valuable colleague Mevlüt Karaçor, who made great contributions to our project titled "TUBITAK 4004 Smart Technologies Designing the Agriculture of the Future" in which he was a researcher.

REFERENCES

Acar, E. (2012). Yapay zeka yöntemleriyle bitki yaprak imgelerinde pas hastalıklarının tespiti. Dicle Üniversitesi Fen Bilimleri Enstitüsü, Yüksek Lisans Tezi (Basılmamış), Diyarbakır.

Akalın, M. (2014). İklim değişikliğinin tarım üzerindeki etkileri: Bu etkileri gidermeye yönelik uyum ve azaltım stratejileri. *Hitit Üniversitesi Sosyal Bilimler Enstitüsü KazakoffDergisi, 7*(2), 351-377.

Anjum, N., Paulraj, A., Blome, C., & Rajkumar, C. (2025). Environmental process design and performance: Understanding the key role of learning by doing and employee empowerment. *International Journal of Production Economics, 109563.*

Araujo, G. (2024). *Using Apprenticeship and Product Based Learning to Improve Programming Outcomes in Introductory Computer Science Courses* (Doctoral dissertation, UC Merced).

Arıkan, H. (2019). İHA ile tarımda sürdürülebilirlik ve hassas uygulamaları ile ayçiçeği hassas gübreleme. İstanbul Teknik Üniversitesi Bilişim Enstitüsü, Yüksek Lisans Tezi (Basılmamış), İstanbul.

Aslan, A. (2019). Buğdayda bitki azot durumunun portatif klorofil ölçüm cihazı (SPAD) ve alçak irtifa insansız hava aracı (Drone) ile belirlenmesi. Harran Üniversitesi Fen Bilimleri Enstitüsü, Yüksek Lisans Tezi (Basılmamış), Şanlıurfa.

Atmatzidou, S., Demetriadis, S., & Nika, P. (2018). How does the degree of guidance support students' metacognitive and problem-solving skills in educational robotics? *Journal of Science Education and Technology, 27*(1), 70–85. doi:10.1007/s10956-017-9709-x

Ayar, M. C. (2015). First-hand experience with engineering design and career interest in engineering: An informal STEM education case study. *Educational Sciences: Theory and Practice, 15*(6), 1655–1675. doi:10.12738/estp.2015.6.0134

Bayraç, H. N., & Doğan, E. (2016). Türkiye'de iklim değişikliğinin tarım sektörü üzerine etkileri. *Eskişehir Osmangazi Üniversitesi İİBF Dergisi, 11*(1), 23-48.

Castro, E., Cecchi, F., Valente, M., Buselli, E., Salvini, P., & Dario, P. (2018). Can educational robotics introduce young children to robotics and how can we measure it? *Journal of Computer Assisted Learning, 34*(6), 970–977. doi:10.1111/jcal.12304

Chang, C. W., Lee, J. H., Wang, C. Y., & Chen, G. D. (2010). Improving the authentic learning experience by integrating robots into the mixed-reality environment. *Computers & Education, 55*, 1572–1578. doi:10.1016/j.compedu.2010.06.023

Demiryürek, M. (2019). Seralarda Arduino ve bileşenlerini kullanarak hassas tarım uygulamalarının ve sistemlerinin geliştirilmesi. Erciyes Üniversitesi Fen Bilimleri Enstitüsü, Yüksek Lisans Tezi (Basılmamış), Kayseri.

Gomoll, A., Hmelo-Silver, C. E., Šabanović, S., & Francisco, M. (2016). Dragons, ladybugs, and softballs: Girls' STEM engagement with human-centered robotics. *Journal of Science Education and Technology, 25*(6), 899–914. doi:10.1007/s10956-016-9647-z

Gomoll, A., Tolar, E., Hmelo-Silver, C. E., Sabanovic, S. (2018). Designing human-centered robots: The role of constructive failure. Thinking Skills and Creativity, 30, 90–102. doi:10.1016/j.tsc.2018.03.001

Gossen, D., & Ivey, T. (2023). The impact of in-and out-of-school learning experiences in the development of students' STEM self-efficacies and career intention.

Güneş, M., Balkışlı, B. Ç., & Özçınar, H. (2024). Oyun tabanlı öğrenmenin öğrenci bağlılığı ve motivasyonu üzerindeki etkisinin kontrol odağına göre incelenmesi. *Journal of Higher Education & Science, 14*(3).

İşler, N. K. (2023). İlkokul sosyal bilgiler dersi öğretim programının sürdürülebilir kalkınma hedefleri ve yenilenmiş Bloom taksonomisi kapsamında incelenmesi. *Afyon Kocatepe Üniversitesi Sosyal Bilimler Dergisi, 25*(2), 472-486.

Jaipal-Jamani, K., & Angeli, C. (2017). Effect of robotics on elementary preservice teachers' self-efficacy, science learning, and computational thinking. Journal of Science Education and Technology, 26(2), 175–192. doi:10.1007/s10956-016-9663-z

Karakoç Topal, O. (2022). Ortaokul öğrencilerinin gözünden bir TÜBİTAK 4004 projesi: Bilimleri birleştir, doğayı güzelleştir! *Dokuz Eylül Üniversitesi Buca Eğitim Fakültesi Dergisi, (53)*, 638-666.

Khor, M. (2009). *The food crisis, climate change and the importance of sustainable agriculture*. Third world network (TWN). sayfa: 18

Kızılay, E. (2018). Ortaöğretim öğrencilerinin STEM alanlarına yönelik kariyer ilgilerinin ve motivasyonlarının incelenmesi. (Doktora Tezi). YÖK Tez Merkezi. (527005).

Kolbe, D. A. (1984). Experiential learning. *New Jersey, Eaglewood Cliffs*, *5*, 1-12.

Küçük, S., & Şişman, B. (2017). Behavioral patterns of elementary students and teachers in one-to-one robotics instruction. Computers & Education, 111, 31–43. doi:10.1016/j.compedu.2017.04.002

Mac Iver, M. A., & Mac Iver, D. J. (2019). "STEMming" the swell of absenteeism in the middle years: Impacts of an urban district summer robotics program. Urban Education, 54(1), 65–88. doi:10.1177/0042085915618712

Milli Eğitim Bakanlığı Yenilik ve Eğitim Teknolojileri Genel Müdürlüğü. (2016). *STEM education report*. https://yegitek.meb.gov.tr/STEM_Education_Report.pdf

Nemiro, J., Larriva, C., Jawaharlal, M. (2015). Developing creative behavior in elementary school students with robotics. Journal of Creative Behavior, 51, 70–90. doi:10.1002/jocb.87

Odabaşı, Ş. Y. (2018). *STEM için ölçme ve değerlendirme.* K. A. Kırkıç & E. Aydın (Eds.), *Merhaba STEM Yenilikçi Bir Öğretim Yaklaşımı*. Eğitim Yayınevi, İstanbul.

Özden, S. 2013. Modern Meyve (Bodur Kiraz) Yetiştiriciliğinde Güneş Enerjili Akıllı Damla Sulama Sistemi Tasarımı. Gazi Üniversitesi Fen Bilimleri Enstitüsü, Yüksek Lisans Tezi (Basılmamış), Ankara.

Robert, K. W., Parris, T. M., & Leiserowitz, A. A. (2005). What is sustainable development? Goals, indicators, values, and practice. Environment: science and policy for sustainable development, 47(3), 8-21.

Scientix (2018). STEM Education Policies in Europe. http://www.scientix.eu/documents/10137/782005/Scientix_Texas-Instruments_STEM-policies-October-2018.pdf/d56db8e4-cef1-4480-a420-1107bae513d5.

Sayın, Z., & Seferoğlu, S. S. (2016). Yeni bir 21. yüzyıl becerisi olarak kodlama eğitimi ve kodlamanın eğitim politikalarına etkisi. *Akademik Bilişim Konferansı, 3*(5), 1-13.

Seçer, İ. (2013). SPSS ve LISREL ile pratik veri analizi: Analiz ve raporlaştırma. Ankara: Anı Yayıncılık

Sönmez, V. & Alacapınar, F. G. (2016). Sosyal bilimlerde ölçme aracı hazırlama. Ankara: Anı Yayıncılık.

Taylor, K., & Baek, Y. (2018). Collaborative robotics, more than just working in groups. Journal of Educational Computing Research, 56(7), 979–1004. doi:10.1177/0735633117731382

Temel, B., & Mumcu, H. Y. (2024). Bilgi işlemsele düşünme etkinliklerinin problem çözmeye yönelik beceri ve tutumlara etkisi. *Eğitim Teknolojisi Kuram ve Uygulama, 14*(2), 310-345.

Yener, Ç. 2019. Tarım Sektörünün Geleceği: Teknolojik Bir Bakış. Çukurova Üniversitesi Sosyal Bilimler Enstitüsü, Yüksek Lisans Tezi (Basılmamış), Adana.

Walter, A., Finger, R., Huber, R., & Buchmann, N. (2017). Opinion: Smart farming is key to developing sustainable agriculture. *Proceedings of the National Academy of Sciences*, *114*(24), 6148-6150.