



STEM-BASED VOCATIONAL WORKSHOP LEARNING: UPPER-SECONDARY STUDENTS' ATTITUDES TOWARD STEM AND THEIR STEM SELF-EFFICACY

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Abstract

STEM-based learning stands out as an important approach in developing students' attitudes toward STEM fields and their perceptions of self-efficacy. The aim of this research was to examine the attitudes of vocational upper-secondary school students toward STEM-based learning and their perceptions of STEM self-efficacy in vocational workshop classes. The research was conducted using a weak experimental design with a single group pre-test and post-test in the 2023–2024 academic year with 30 ninth-grade students studying in the field of Electrical-Electronics Technology at a vocational and technical secondary school in Türkiye. The data were collected through the STEM Attitude Scale and the STEM Self-Efficacy Scale administered before and after the four-week STEM-based teaching application. Descriptive statistics, paired sample t-test, and Pearson correlation analysis were used in the data analysis. The findings showed that the STEM-based teaching practice was associated with positive changes in students' attitudes toward STEM and their perceptions of STEM self-efficacy. Additionally, a statistically significant and positive relationship was identified between students' attitudes toward STEM and their perceptions of STEM self-efficacy. The findings suggest that the integration of STEM-based learning into vocational workshop courses can support students' attitudes toward STEM and their perceptions of self-efficacy.

Keywords: attitude toward STEM, self-efficacy, STEM-based learning, vocational workshop learning

Introduction

Rapid technological transformations in the 21st century require individuals to possess knowledge and to apply this knowledge to generate innovative solutions, think critically, collaborate effectively, and solve complex problems. In this context, STEM (Science, Technology, Engineering, and Mathematics) based learning, which integrates these disciplines through an interdisciplinary approach, has emerged as an effective educational model that encourages students to develop solutions to real-world problems from multiple perspectives (Bybee, 2013).

STEM-based learning enhances academic achievement and contributes to the development of higher-order cognitive and affective skills such as creativity, problem-solving, critical thinking, and self-efficacy (Bandura, 1997). Particularly in vocational and technical education institutions, STEM-based instructional practices enable students to concretize their vocational knowledge and skills and actively engage in learning processes (Nurtanto et al., 2020). In this respect, vocational workshop courses constitute important learning environments where theoretical knowledge is transformed into practice and where STEM approaches can be effectively integrated.

STEM-based learning emphasizes interdisciplinary instruction, project- and problem-based learning, engineering design processes, and real-world contexts (Corlu et al., 2014; Daugherty & Carter, 2018). Within this approach, students participate in iterative learning processes involving designing, testing, evaluating, and redesigning, thereby enhancing their critical thinking and scientific reasoning skills (Guzey et al., 2016). Errors are regarded as a natural part of learning, and students are encouraged to engage in evidence-based decision-making processes (Smyrniou et al., 2015). The literature highlights that STEM-based learning significantly contributes to the development of 21st-century skills such as problem-solving, creativity, collaboration, communication, and self-confidence (Anderson & Krathwohl, 2001; Morrison, 2006; Sanders, 2009). Moreover, STEM approaches support structured and iterative learning tasks that facilitate students' progression toward higher levels of cognitive achievement (Brophy et al., 2008; Moore et al., 2014).

In the context of vocational and technical education, STEM-based learning is regarded as a key strategy for strengthening Technical and Vocational Education and Training (TVET) systems (Voogt & Roblin, 2012). STEM education supports the development of technical competencies demanded by the labour market, enhances employability, and contributes to economic growth (Tikly et al., 2018). Accordingly, many countries support STEM education at the national policy level and aim to cultivate a STEM-literate society through collaboration among education, industry, and public institutions (National Research Council, Division of Behavioral, Social Sciences, Board on Science Education (NRC), 2012). Students' attitudes toward STEM and their self-efficacy perceptions play a critical role in the effectiveness of STEM education. While attitude refers to individuals' positive or negative tendencies toward STEM fields, self-efficacy reflects their belief in their ability to successfully perform specific tasks (Bandura, 1997). Previous research indicated that positive attitudes toward STEM and high levels of self-efficacy promote active engagement in learning processes and support sustained learning outcomes in STEM-related domains (Böse & Brauckmann-Sajkiewicz, 2021).

In the Turkish educational context, increasing emphasis has been placed on interdisciplinary learning, and the STEM approach has been strongly aligned with national curriculum objectives for nearly a decade (Ministry of National Education (MoNE), 2016). This alignment has been further institutionalized with the implementation of the Türkiye Century Education Model in 2024, which represents a paradigm shift toward a holistic educational vision that prioritizes students' cognitive, affective, social, and practical development alongside academic achievement (MoNE, 2025). The model explicitly emphasizes learning environments in which knowledge is integrated across disciplines and applied to real-life contexts, principles that closely correspond to STEM-based learning.

The integration of STEM-based learning into vocational workshop courses emerged as a particularly critical area of inquiry (Voogt & Roblin, 2012). Vocational education provides authentic, practice-oriented settings that are well suited for interdisciplinary, design-based, and problem-centred STEM applications (Moore et al., 2014). However, despite the strong policy emphasis on STEM and holistic development, empirical evidence regarding the emotional outcomes of STEM-based learning for vocational education students, particularly its impact on their attitudes toward STEM and STEM self-efficacy, is limited. STEM self-efficacy is based on

social cognitive theory and is closely related to students' motivation, learning behaviours, and willingness to engage in challenging tasks (Bandura, 1997). Positive attitudes toward STEM and strong self-efficacy perceptions are mutually reinforcing and serve as key mechanisms through which instructional interventions translate into long-term educational and vocational outcomes.

This study aimed to examine the effects of STEM-based learning implemented in vocational workshop courses on students' attitudes toward STEM and their STEM self-efficacy perceptions. By situating STEM-based learning within the framework of the Türkiye Century Education Model, this study seeks to address an important gap in the literature and provide empirical evidence to inform curriculum development, instructional practices, and policy decisions in vocational education.

Theoretical Framework

In educational sciences, attitude is considered one of the key variables determining students' active engagement in learning processes. From a social psychological perspective, attitude is defined as a relatively enduring evaluative tendency toward an object, situation, or phenomenon, consisting of cognitive, affective, and behavioural components (Eagly & Chaiken, 1993). Ajzen (1980) conceptualized attitude as an individual's evaluative disposition toward a particular object and argues that such evaluations play a significant role in shaping behaviour. Attitudes toward learning are related to students' motivations, interests, and perceptions of self-efficacy in the learning process. From this perspective, these cognitive and emotional characteristics can play a role in how students approach the learning process and how they behave during this process (Bandura, 1997). Therefore, attitude is considered one of the important variables to be considered in educational research to understand students' learning experiences and interactions in the teaching process.

Attitudes toward scientific disciplines such as science, mathematics, technology, and engineering have long been a focus of educational research, as they are closely associated with students' interest, confidence, anxiety, achievement beliefs, and career orientations in these fields (Osborne et al., 2003). These attitudes begin to develop in the early stages of cognitive development and are shaped over time by pedagogical approaches, social environments, and students' learning experiences (Singh et al., 2002). As an interdisciplinary learning model, the STEM approach aims to enhance students' academic knowledge and to develop higher-order skills such as critical thinking, problem solving, creativity, collaboration, and innovation by connecting disciplinary knowledge to real-world contexts (English, 2016). Attitudes toward STEM are defined as a multidimensional construct encompassing students' interest in STEM disciplines, self-efficacy beliefs, academic motivation, and career intentions (Unfried et al., 2015). Research indicated that positive attitudes toward STEM are positively associated with academic achievement, whereas negative attitudes may lead to disengagement from STEM fields and decreased interest in STEM-related careers (Khan et al., 2021).

In the context of vocational and technical education, the STEM approach enables students to integrate occupational skills with higher-order thinking competencies. STEM-based practices support students in becoming users of technology and designers, problem solvers, and innovators (Yıldırım & Selvi, 2017). In this regard, students' attitudes toward STEM play a decisive role in shaping their engagement in practical courses, motivation to develop designs, willingness to produce technological solutions, and participation in collaborative learning activities (Mohr-Schroeder et al., 2014). Empirical studies demonstrated that STEM-based learning environments in vocational and technical education positively influence students' problem-solving skills, self-efficacy beliefs, and attitudes toward STEM disciplines (Şahin et al., 2014). Instructional strategies such as project-based learning, the engineering design

process, and workshop-based practices are reported to be particularly effective in fostering positive attitudes toward STEM (Şahin et al., 2014). In conclusion, identifying and enhancing attitudes toward STEM in vocational and technical education is crucial for improving the effectiveness of teaching and learning processes and for supporting the development of a qualified workforce, achieving sustainable development goals, and promoting lifelong learning competencies (OECD, 2019, 2020).

Vocational and technical education improves the quality of the workforce and contributes to the transformation of the labour market by equipping individuals with essential professional competencies (Gessler & Howe, 2015). Vocational and technical education offers an interdisciplinary learning environment that integrates mathematical calculations, physical principles, and the use of technological tools through workshop courses in different fields and learning outcomes based on measurement and application. This holistic structure naturally makes vocational workshop courses suitable for STEM-based teaching designs, while also allowing students to connect the knowledge they acquire in school with real-life and professional problems. Aydın et al. (2024) found that a STEM-based learning scenario integrating vocational workshop courses with different disciplines significantly improved students' problem-solving and 21st-century skills. Thus, STEM applications support students' conceptual understanding and vocational skills in the context of vocational education (Wannapiroon et al., 2021).

STEM-based learning approaches play a critical role in transforming theoretical knowledge into practical and innovative applications, while real-life and socially relevant contexts increase students' active participation and motivation in the learning process (Sobel, 2004). In this regard, empirical studies conducted in different countries found that integrating STEM and STEAM-based approaches into vocational education strengthens students' learning motivation and alignment with industry needs, as well as their professional and interdisciplinary skills, and contributes to students developing as individuals capable of developing innovative and entrepreneurial characteristics (Feng & Hou, 2023; Hwong, 2021; Panulinova & Harabinova, 2023).

STEM Self-efficacy

As individuals' self-efficacy beliefs strengthen, they tend to set higher goals and demonstrate stronger commitment to achieving them (Bandura, 1997). These beliefs are primarily shaped by mastery experiences, task-specific performances, and individuals' interpretations of these experiences (Rittmayer & Beier, 2008). Research demonstrated that engaging learners in authentic, real-world problem-solving experiences positively influences their self-efficacy beliefs (Dunlap, 2005; Rittmayer & Beier, 2008). Students with higher STEM self-efficacy are more likely to actively participate in interdisciplinary tasks, persist in challenging problem-solving situations, and transfer knowledge across disciplines (Britner & Pajares, 2006; Lent et al., 1994).

Emerging research suggested that STEM-based instructional practices can positively influence students' self-efficacy perceptions by providing opportunities for hands-on learning, interdisciplinary integration, and authentic problem solving (Moore et al., 2014). Given the applied and practice-oriented nature of vocational education, determining students' self-efficacy levels and examining whether STEM-based learning scenarios lead to significant changes in these perceptions is of particular importance. However, studies examining STEM self-efficacy at the student level, particularly within vocational and technical education contexts, are still relatively limited. Investigating STEM self-efficacy in vocational workshop settings can provide valuable insights into how STEM integration can support students' confidence in applying scientific, technological, engineering, and mathematical knowledge in real-world professional contexts.

This study aims to contribute to the limited body of literature by examining the effects of STEM-based learning approaches implemented in vocational workshop courses on students' attitudes toward STEM and their STEM self-efficacy perceptions. Moreover, the findings obtained from student-centred variables such as attitudes toward STEM and STEM self-efficacy perceptions are expected to provide valuable insights for the development of future curricula, teacher training programs, and school-based practices. The results of this research may offer empirical evidence that supports improving the quality and effectiveness of learning processes in vocational education, enhancing student motivation, and promoting academic achievement. In this respect, the study serves to strengthen the vocational education system by providing significant contributions to both educational policies and practitioners at theoretical and practical levels. Thus, the main aim of this study was to examine the effects of STEM-based learning approaches implemented in vocational workshop courses conducted in vocational and technical Anatolian upper-secondary schools on students' attitudes toward STEM and their STEM self-efficacy perceptions. Within this framework, the study focused on understanding students' perceptions of STEM disciplines and their self-efficacy beliefs regarding their competencies in these areas, as well as revealing the relationship between these variables.

Research Questions

Does the STEM-based learning approach affect students' attitudes toward STEM?

Does the STEM-based learning approach affect students' perceptions of STEM self-efficacy?

Is there a significant relationship between students' attitudes toward STEM and their perceptions of STEM self-efficacy?

Do attitudes toward STEM differ based on gender, parental education level, and whether parents work as technical staff?

Do STEM self-efficacy perceptions differ based on gender, parental education level, and whether parents work as technical staff?

Research Methodology

Design

This study is quantitative research employing a weak experimental design, specifically a single-group pretest–posttest design, in conjunction with a correlational survey model. The study examined the effects of STEM scenario-based teaching on students' attitudes toward STEM and their STEM self-efficacy perceptions. Following the pretest administration, a STEM scenario titled “*Eco-Friendly Charging Station for Electric Vehicles*” (A brief version of the scenario is available in Appendix 1) was implemented with the sample over a four-week period, totalling 40 class hours. The scenario was designed by subject-matter expert teachers based on the 5E instructional model (Engage, Explore, Explain, Elaborate, Evaluate) proposed by Bybee (2009). Prior to implementation, the scenario was piloted in another class within the same school to identify and address potential shortcomings. Due to the presence of only one class at the grade level in the electrical-electronics technology department at the participating school, the formation of experimental and control groups was not feasible.

Within the STEM scenario, electric vehicles were addressed as a potential solution for reducing carbon footprints, one of the major causes of environmental problems. When the electricity used to charge such vehicles is derived from renewable energy sources, electric vehicles can operate without generating carbon emissions, thereby enabling environmentally friendly transportation. Through this learning scenario, students designed a parking area

and electric vehicle charging unit powered by solar energy panels, drawing upon their prior knowledge of environmental issues, fossil fuels, carbon footprints, and solar energy systems. Throughout the process, students had opportunities to engage in hands-on applications alongside theoretical and technical learning.

Following the intervention, posttest data were collected and analysed to examine the relationship between students' attitudes toward STEM and their STEM self-efficacy perceptions within the framework of the correlational survey model. Thus, both post-intervention changes and the relationships between variables were evaluated comprehensively (Creswell, 2017; Karasar, 2022). In this study, the independent variable was the implemented STEM scenario to the ninth grade students in a vocational and technical upper-secondary school during an academic year, while the dependent variables were students' attitudes toward STEM and their STEM self-efficacy perception levels.

Group

The population of the study consisted of students enrolled in the field of Electrical and Electronics Technology at Vocational and Technical Anatolian Upper-secondary school during the 2023–2024 academic year. The study group comprised 30 ninth-grade students studying in the field of Electrical and Electronics Technology at a Vocational and Technical Upper-secondary School located in Türkiye during the same academic year. Since the research was conducted with a single-group pretest–posttest design aimed at implementing STEM-based learning practices in a real classroom environment, the entire class where the implementation took place was included in the study group. Therefore, the sample size is limited by the number of accessible participants in the educational environment where the research is conducted. In determining the sample, convenience sampling, one of the purposive sampling methods, was employed. This method considers situations that the researcher can easily access and from which data can be readily collected. Convenience sampling is frequently preferred in applied educational research due to the advantages it offers in terms of time efficiency, accessibility, and ease of implementation (Yıldırım & Şimşek, 2018).

Table 1
Demographic Characteristics of the Students

Gender	f	Father's Education Level	f	Mother's Education Level	f
Female	5	Master's Degree	2	Master's Degree	1
Male	25	Bachelor's Degree	16	Bachelor's Degree	18
		Upper-secondary	9	Upper-secondary	5
		Lower-secondary	2	Lower-secondary Middle School	2
		Primary School	1	Primary School	4

As shown in Table 1, the research group consisted of a total of 30 students, including 5 female and 25 male students. Since the participants were enrolled in a Vocational and Technical Anatolian High School, they had a high level of familiarity with basic materials and equipment related to STEM applications. Due to their workshop-based learning experiences, students possessed well-developed practical skills in recognizing various materials, selecting appropriate ones, and assembling them to produce functional products.

Data Collection Instruments

To measure students' attitudes toward STEM, the STEM Attitude Scale, developed by Faber et al. (2013) and adapted into Turkish by Özyurt and colleagues (2018), was utilized. This 5-point Likert-type scale consists of a total of 37 items, including 8 items in the mathematics sub-dimension, 9 items in the Science sub-dimension, 9 items in the Engineering and Technology sub-dimension, and 11 items in the 21st Century Skills sub-dimension. Reliability analysis of the STEM Attitude Scale yielded a Cronbach's alpha coefficient of .936 for the pre-test and .885 for the post-test.

To examine students' perceptions of STEM self-efficacy, the STEM Self-Efficacy Perception Scale, developed by Tekin (2022), was administered. The scale consists of 28 items. Reliability analysis results indicated Cronbach's Alpha coefficient of .975 for the pre-test and .912 for the post-test. According to the relevant literature, Cronbach's alpha values of .80 and above indicate a high level of reliability for measurement instruments (Nunnally & Bernstein, 1994; Tavşancıl, 2002). The findings demonstrate that both the STEM Attitude Scale and the STEM Self-Efficacy Perception Scale possess high internal consistency and are reliable instruments for use within the scope of this study.

Data Collection Process

The data collection process began with the administration of the STEM Attitude Scale and the STEM Self-Efficacy Perception Scale to the students as pre-tests. Following the implementation of the STEM scenario titled "*Eco-Friendly Charging Station for Electric Vehicles*" (Appendix 1), which was developed by the researchers, the same scales were administered as post-tests. The collected data were transferred to SPSS 26.0 (Statistical Package for the Social Sciences) for analysis.

In the analysis of the data obtained from the study, descriptive statistics such as frequency, arithmetic mean, standard deviation, and percentage values were used. To determine whether there were significant differences between the variables related to the sub-problems of the study, a paired samples t-test was employed. In addition, the Pearson correlation coefficient was calculated to examine the relationship between students' STEM attitudes and STEM self-efficacy perception scores.

Data Analysis

The research data were analysed using SPSS 26.0, and the normality assumption of the data was tested using the Shapiro–Wilk test. Since the STEM attitude pre-test ($p = .17 > .05$), STEM attitude post-test ($p = .57 > .05$), STEM self-efficacy perception pre-test ($p = .059 > .05$), and STEM self-efficacy perception post-test ($p = .101 > .05$) data showed a normal distribution, parametric tests were applied. Accordingly, a paired sample t-test was used to analyse the differences between pre-test and post-test scores.

Research Results

Differences Between STEM Attitude Pre-Test and Post-Test Scores

Paired samples t-test results are presented in Table 2.

Table 2
Paired Samples t-Test Results for STEM Attitude Pre-Test and Post-Test Scores

Measure	Test	N	M	SD	df	t	p
STEM Attitude	Pre-test	30	138.80	14.25	29	4.24	.01
	Post-test	30	145.53	14.09			

$p < .05$

As shown in Table 2, the mean pre-test score of students' STEM attitudes was $M = 138.80$, while the mean post-test score was $M = 145.53$. The difference between the means was analysed using a paired sample t-test, and the results indicated a statistically significant difference, $t(29) = 4.24$, $p < .05$. According to Cohen's (1988) benchmarks, the effect size ($d = 0.77$) was approaching a large effect. These findings suggest that STEM scenario-based instructional activities had a positive effect on students' attitudes toward STEM.

Differences Between STEM Self-Efficacy Pre-Test and Post-Test Scores

The paired samples t-test results are presented in Table 3.

Table 3
Paired Samples t-Test Results for STEM Self-Efficacy Perception Pre-Test and Post-Test Scores

Measure	Test	N	M	SD	df	t	p
STEM Self-Efficacy	Pre-test	30	116.47	7.00	29	5.88	.01
	Post-test	30	124.80	9.76			

$p < .05$

As shown in Table 3, the mean pre-test score of students' STEM self-efficacy perception was $M = 116.47$, whereas the mean post-test score was $M = 124.80$. The paired samples t-test results revealed a statistically significant difference between the means, $t(29) = 5.88$, $p < .05$. According to Cohen's (1988) benchmarks, the effect size ($d = 1.07$) indicated a large effect. These results reveal that the STEM scenario-based instructional activities positively influenced students' STEM self-efficacy perceptions.

Relationship Between STEM Attitude and STEM Self-Efficacy

Pearson correlation analysis was conducted since both pre-test and post-test data demonstrated normal distribution. The results are presented in Tables 4 and 5.

Table 4
Correlation Coefficients Between Pre-Test Scores

Sub-Dimensions	<i>r</i>	<i>p</i>
Mathematics	.287	.12
Science	.376	.04*
Engineering and Technology	.269	.15
21st Century Skills	.181	.33

$p < .05$

As shown in Table 4, among the STEM attitude sub-dimensions, only the Science pre-test scores were found to have a low-level, positive, and statistically significant correlation with STEM self-efficacy pre-test scores ($r = .376$, $p < .05$).

Table 5
Correlation Coefficients Between Post-Test Scores

Sub-Dimensions	<i>r</i>	<i>p</i>
Mathematics	.423	.02*
Science	.432	.01*
Engineering and Technology	.241	.20
21st Century Skills	.060	.73

$p < .05$

As shown in Table 5, a moderate, positive, and statistically significant correlation was found between the mathematics post-test scores and STEM self-efficacy post-test scores ($r = .423$, $p < .05$). Additionally, a moderate, positive, and statistically significant relationship was observed between the Science post-test scores and STEM self-efficacy post-test scores ($r = .432$, $p < .05$).

Differences Based on Demographic Variables

Independent samples t-tests and one-way ANOVA tests were conducted. For each scale, pre-test and post-test data were normally distributed across gender, and variances were homogeneous. However, the independent samples t-test results indicated that there were no statistically significant differences in STEM attitude or STEM self-efficacy perception scores based on gender.

Similarly, for each scale, pre-test and post-test data showed normal distribution and homogeneity of variance across parental education levels. The results of the one-way ANOVA revealed no statistically significant differences in STEM attitude or STEM self-efficacy perception scores based on parental education level. Students whose mother or father worked as a technician, electronics teachers, or engineers were categorized under the technical parent variable, and independent samples t-tests were conducted for each scale. A statistically significant difference was found only in the STEM attitude pre-test scores based on whether students had a parent working in a technical profession.

Table 6

Normality Test Results of STEM Attitude Pre-Test Scores Based on Having a Parent Who is Technical Personnel

Group	N	M	Shapiro-Wilk
Technical	5	141.08	.124
Non-technical	25	124.40	.777

As shown in Table 6, the mean STEM attitude pre-test score of the five students whose mother or father was technical personnel was 141.08, while the mean score of the 25 students whose parents were not technical personnel was 124.40. An independent sample t-test was conducted to determine whether this difference was statistically significant.

Table 7

Independent Samples t-Test of STEM Attitude Pretest Scores by Parental Technical Occupation

Group	N	M	SD	df	Levene's Test (p)	t	p
Technical	5	141.08	11.747	28	.144	2.618	.014
Non-technical	25	124.40	18.876				

$p < .05$

As shown in Table 7, Levene's test result ($p = .144 > .05$) indicated that variances were homogeneous. According to the independent samples t-test results ($p = .014 < .05$), students whose mother or father was technical personnel had significantly higher STEM attitude pre-test scores than those whose parents were not technical personnel.

Discussion

This study examined the effects of STEM scenario-based educational activities implemented in vocational workshop courses on students' attitudes toward STEM and their STEM self-efficacy perceptions. The findings indicate that the STEM-based learning approach was associated with significant and positive effects on students' affective and cognitive outcomes.

Existing literature established that student attitudes and self-efficacy are core cognitive and affective constructs governed by established theoretical frameworks. A broad body of research indicated that STEM-based, project-oriented, and problem-based instructional practices foster positive attitudes across diverse learner groups, including female students (Yıldırım & Türk, 2018), seventh-grade students (Uğraş, 2018), pre-service science teachers (Şahin, 2019), gifted students (Kalik & Kırındı, 2022), and middle school students (Sarı et al., 2018). More recent studies similarly confirm that STEM-based learning environments positively influence student interest and attitudes toward STEM disciplines (Li et al., 2020; Wahono et al., 2020), aligning with the fundamental educational goals of interdisciplinary integration and higher-order thinking (Bybee, 2013; Kelley & Knowles, 2016).

Regarding self-efficacy, Bandura's (1997) social cognitive theory defines it as individuals' beliefs in their capabilities to successfully perform tasks, playing a critical role in learning processes through active participation, hands-on experiences, and real-life contexts

that generate mastery experiences. Previous research demonstrates that similar intervention approaches enhance self-efficacy and activity design skills among science teachers (Kurtulan, 2021; Sütçü et al., 2023) and boost confidence and real-world application competencies among upper-secondary students (Kuchynka et al., 2021; Şahin et al., 2014). Furthermore, extensive literature highlights that sociocultural and environmental factors such as immediate STEM role models, parental support, and professional exposure play a critical role in shaping students' STEM career awareness, attitudes, and self-efficacy beliefs (Archer et al., 2020; DeWitt et al., 2019; Tekin, 2022).

While prior studies have documented the benefits of STEM interventions across various academic levels and teacher groups, this study extends empirical evidence specifically into a vocational and technical upper-secondary educational setting traditionally underrepresented in empirical STEM research. By embedding scenario-based activities into vocational workshop courses (such as Electrical and Electronics Technology), this research demonstrates how practice-oriented technical environments naturally facilitate the mastery experiences and active engagement theorized by Bandura (1997).

Additionally, this study contributes valuable insights regarding demographic and environmental variables within vocational tracks. While some literature notes gender-based variations in self-efficacy (Tekin, 2022), the absence of significant gender differences observed here consistent with findings by George and colleagues (2020) suggests that well-designed, practice-oriented STEM learning environments can provide equitable learning opportunities regardless of gender. Finally, by confirming that students with parents employed as technical personnel demonstrate significantly higher attitudes toward STEM, this study reinforces the powerful role of familial and environmental capital, supporting evidence that immediate professional role models significantly influence student dispositional orientations in vocational educational contexts (Tekin, 2022).

Conclusions and Implications

This study demonstrated the integration of STEM scenario-based educational activities into vocational workshop courses to understand how practice-oriented environments shape students' affective and cognitive orientations. Aligning technical education with interdisciplinary, real-world problem-solving serves as a vital pathway for fostering student engagement and confidence. Within this sample, the implementation of structured STEM scenarios was associated with notable improvements in students' attitudes toward STEM and their self-efficacy perceptions. Furthermore, the absence of performance disparities across genders highlights the potential of inclusive, hands-on instructional designs to foster equitable learning environments, while the influence of familial technical backgrounds emphasizes the role of social capital in shaping student dispositional orientations. Ultimately, embedding authentic problem-solving within vocational education provides an effective educational approach to cultivating a capable and confident workforce.

Limitations of the Study

Despite its contributions, this study has several methodological limitations that should be acknowledged. First, the research employed a single-group pretest–posttest design without a control group, which limits the ability to make causal inferences regarding the effects of STEM-based vocational workshop learning. Second, the sample consisted of a relatively small number of students from a single vocational and technical upper-secondary school and a single vocational field, which may restrict the generalizability of the findings.

The fact that the research was conducted in a single school, in a single vocational field, and with a study group of 30 students limits the generalizability of the findings. Therefore, the results should be interpreted for similar contexts; they should be supported by future studies conducted with larger and different vocational education samples.

Additionally, the intervention was implemented over a relatively short period, and the data were collected through self-report instruments, which may be subject to response bias. Future studies could employ experimental or mixed-methods designs with larger and more diverse samples, include control groups, and integrate qualitative data sources to provide deeper insights into students' STEM-related learning experiences.

Theoretical and Practical Implications

The findings of this study contribute to the literature by extending empirical evidence to vocational and technical secondary education, a domain traditionally underrepresented in STEM research. By demonstrating that structured STEM interventions were associated with improvements in students' attitudes toward STEM and their self-efficacy perceptions within this sample, the study aligns with social cognitive theory, reinforcing Bandura's (1997) framework regarding mastery experiences and contextual learning. The observed positive relationship between STEM attitudes and self-efficacy further supports theoretical models emphasizing reciprocal interactions between affective and cognitive motivational constructs. Additionally, the lack of significant gender-based differences suggests that well-designed, practice-oriented learning environments can help mitigate traditional gender disparities. Finally, the finding that students with family members employed in technical professions exhibited higher baseline attitudes underscores the relevance of sociocultural and ecological perspectives in shaping student motivation and career orientations.

From a practical perspective, the results of this study suggest several implications for educators, curriculum developers, school administrators, and policymakers, particularly within vocational and technical education settings. Specifically, vocational curricula should incorporate interdisciplinary STEM scenarios aligned with occupational competencies and real-world industrial problems to bridge theoretical knowledge with practical application. Additionally, professional training programs must equip vocational educators with the pedagogical competencies required to design and implement scenario- and project-based STEM activities effectively. Schools should also establish partnerships with technical professionals and industry experts to serve as mentors and role models, enhancing students' career awareness and professional identity. Finally, educational authorities should support resource allocation and infrastructure development, ensuring access to digital tools and technical equipment that facilitate sustainable interdisciplinary teaching approaches.

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Competing Interest

The authors have no competing interests to declare that are relevant to the content of this article.

Ethics Approval

This study was approved by the TED University Human Research Ethics Committee under approval number 2024-41. All procedures performed in this study involving human participants were conducted in accordance with the ethical standards of the institutional research committee.

Consent to Participate

Written informed consent was obtained from all student participants and their parents/guardians prior to data collection.

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APPENDIX 1

ECO-FRIENDLY CHARGING STATION FOR ELECTRIC VEHICLES

Electric vehicles are emerging as a significant solution in preventing carbon footprint, one of the biggest causes of environmental problems. However, the question of how these vehicles will be charged is another question awaiting an answer. If the source of the charge for electric vehicles is not renewable energy, the vehicle still generates a carbon footprint. Furthermore, the lack of widespread electric vehicle charging stations in our country is a cause for concern for buyers and users. Using this learning scenario, students will design a parking lot and vehicle system that includes an electric vehicle charging unit with solar panels, utilizing their knowledge of environmental problems, fossil fuels, carbon footprint, and solar energy systems. Throughout the process, students will gain both theoretical and technical knowledge as well as practical application.

Keywords

Electric vehicles, charging, solar energy, project-based

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Overview

<i>Lessons</i>	Mathematics, Electricity, Geography, Technology and Engineering, Basic Electrical and Electronics Workshop Course
<i>Subject(s)</i>	Environmental issues, research into energy types, fossil fuel problems, renewable energy production for electric vehicles, 3D parking garage design, parking garage prototype model making, powering an electric vehicle with energy from solar panels.

<i>Outcomes</i>	English: E9.4.R1. Students will be able to identify specific information in simple written material such as short newspaper articles on effects of natural events. E9.4.L1. Students will be able to identify the subject of a text with the help of familiar words. E9.4.W2. Students will be able to write a short paragraph about love for nature. Geography: 9.1.1. Explains the interaction between nature and humans with examples. 9.1.4. Evaluates the effects of the Earth's shape and movements. 9.1.5. Makes inferences about time and location characteristics using a coordinate system. Maths: 9.3.2.2. Performs applications related to GCD and LCM in integers. 9.3.5.1. Solves problems using the concepts of ratio and proportion. 9.3.5.2. Solves problems involving equations and inequalities. 9.5.2.2. Represents and interprets data sets reflecting real-life situations using appropriate chart types. Technology and Engineering: He/She creates a calculation in an online drawing program (Tinkercad) and uses the program's interface. It creates a three-dimensional model of a vehicle charging station powered by solar (photovoltaic) energy panels, adhering to strict modeling principles. Basic Electrical and Electronics Workshop Course: It describes the protective equipment used in the mechanical workshop. It describes the hand tools used in a mechanical workshop. The company performs measuring and cutting operations while taking occupational health and safety precautions. The filing process is carried out while taking occupational health and safety precautions. The company performs drilling and screwing operations while taking occupational health and safety precautions. He/she installs the solar (photovoltaic) energy panels while taking occupational health and safety measures. He/she makes the conductive connections of solar (photovoltaic) energy panels while taking occupational health and safety measures. The battery charging system is installed while taking occupational health and safety measures. He performs soldering applications on battery charging systems while taking occupational health and safety measures. While taking occupational health and safety measures, it makes the conductive connections between solar (photovoltaic) energy panels and the battery charging system. It measures current and voltage in electronic circuits while taking occupational health and safety measures. It measures work and power in an electrical circuit while taking occupational health and safety precautions.
<i>Students' age</i>	14-18
<i>Time to prepare</i>	4 hours

<i>Teaching time</i>	Mathematics: 3 hours Geography & English: 3 hours of instruction on environmental issues and energy types, carbon footprint calculation, toolbox, practice plan. Electricity: Current, circuit, 3 hours Renewable Energy: solar panel operating system 9 hours Technology: 3D design, 4 hours Engineering: Prototype model construction 18 hours
<i>Online teaching material</i>	Internet connection, interactive whiteboard (IWB), The teacher's laptop, and several tablets/laptops/computers to share among pairs/groups of students. Online videos (see below), online websites/applications.
<i>Offline teaching material</i>	
<i>Resources used</i>	https://scratch.mit.edu/ https://www.youtube.com/watch?v=jAa58N4Jlos https://climateknowledgeportal.worldbank.org/country/turkiye/climate-data-historical https://yesilbiradim.com/hesaplama https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Energy statistics - an overview#:~:text=Renewable%20energies%20accounted%20for%20the,renewable%20waste%20(%2.4%20%25). https://waqi.info/#/c/9.974/52.846/3.6z http://has.concord.org/air-pollution.html http://has.concord.org/air-pollution-aerial.html https://www.geogebra.org/m/q8r79zkm

The aim of the course

The aim of this learning scenario is to raise students' awareness of environmental issues and renewable energy sources, so that they can design a parking lot that generates electricity with solar panels using 3D design and digital skills, enabling electric vehicles to operate without a carbon footprint.

Disposition

STEM-based learning, problem-solving, creative thinking, teamwork, interaction, collaboration

21st century skills

Through research, interdisciplinary studies, project-based learning, STEM-based learning models, collaborative learning, peer learning, problem-solving, creative thinking, critical thinking, digital literacy, and digital design, students will improve themselves in these areas thanks to this learning scenario.

STEM Strategy Criteria

Job Connections: Within the context of this Learning Scenario, students will develop their professional skills through hands-on work in a workshop setting.

Interdisciplinary teaching: In this learning scenario, a range of activities will be explored and implemented in relation to English, geography, mathematics, physics, and the achievements related to electricity and renewable energy.

Continuous assessment: A scale and exercises will be applied to evaluate the skills students acquire and the progress they make with the STEM plan.

Problem-based learning (PBL): Students will work on promoting the use of renewable energy for charging electric vehicles to minimize their carbon footprint. Group work will facilitate knowledge acquisition, improved team collaboration, and communication.

High level of collaboration among staff: Teachers from different subjects will work collaboratively to implement the STEM scenario. Regular collaboration and team planning sessions are held to promote effective communication with colleagues. This practice ensures that teachers are effective and have peers they can collaborate with and rely on during challenging times.

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