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The Effect of Interdisciplinary Practices on Prospective Science Teachers' STEM Awareness and Thoughts

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This study examined prospective science teachers' STEM awareness and their thoughts on interdisciplinary practices implemented in an Interdisciplinary Science Teaching course. The study was conducted with 66 fourth-year prospective science teachers at a state university in Türkiye over a 14-week period. A mixed-methods research design was used. Quantitative data were collected using the STEM Awareness Scale in a single-group pre-test/post-test design, while qualitative data were collected through weekly self-assessment forms and an Interdisciplinary Science Teaching Course Evaluation Questionnaire. The quantitative findings indicated a statistically significant increase in participants' STEM awareness after the course. Qualitative findings showed that prospective teachers found activity-based interdisciplinary practices and discussion-based learning environments beneficial. Based on the findings, it is suggested that interdisciplinary STEM activities emphasizing active participation should be integrated into teacher education courses and supported with adequate instructional infrastructure.

Keywords: interdisciplinary science teaching, STEM awareness, prospective science teachers

INTRODUCTION

The national science curriculum of Türkiye for grades 3-8 (National Ministry of Education [NME], 2018a) includes guidance on modern learning strategies, methods, techniques, and field-specific skills, as well as new roles for teachers and students. This curriculum adds "Engineering and Design Skills" as field-specific skills, and provides explanations of science, engineering, and entrepreneurship practices under a separate heading. In this context, interdisciplinary learning has gained importance as an approach that integrates knowledge and practices from multiple disciplines to provide a holistic perspective. The main aim of this approach is to apply knowledge obtained from various disciplines to a specific purpose (Demirel & Coşkun, 2010). An interdisciplinary approach focuses on a central problem, issue, or theme and draws upon the methodologies, interpretive tools, and languages of various disciplines (Ivanitskaya et al., 2002; Jacobs, 1989). Such environments also foster fundamental lifelong learning skills such as critical thinking, communication, and creativity (Jones, 2010).

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STEM (Science, Technology, Engineering, Mathematics) education is considered one of the most important educational approaches today, as it fosters the production of science and technology, supports engagement with engineering, promotes interdisciplinary thinking, and enables learners to develop tangible solutions to real-world problems (NME, 2018b). STEM content is a blend of interdisciplinary and integrated knowledge that can be applied to global problems and to carefully selected local problems (Rennie, 2015). Through activities that integrate science, technology, engineering, and mathematics, STEM education prepares individuals to address complex challenges while fostering collaboration and teamwork (Sheth & Pathak, 2023). It also supports the development of effective solutions to problems with an interdisciplinary perspective and fosters the creation of innovative products across all domains of life (Şahin, 2022). Furthermore, different approaches provide teachers with flexibility in integrating STEM into their classes (Roehrig et al., 2012).

Despite these advantages, the traditional single-disciplinary approaches in the school curriculum fails to adequately prepare students to understand and interact with this complexity (Fensham, 2015). Interdisciplinary curricula, in contrast, are designed as creative, integrative solutions that enable students to examine problems from multiple perspectives and function effectively in complex environments (Jacobs, 1989). Previous studies have shown that interdisciplinary and STEM-based approaches enhance students' problem-solving, collaboration, and innovation skills. For example, STEM-based interventions emphasizing the engineering design process have been found to significantly improve students' creative problem-solving abilities and the quality of their products (Puchongprawet & Chantraukrit, 2022). Similarly, the development of STEM-integrated instructional materials has been reported to support students' creative thinking and engagement in learning processes (Pangestu & Hidayah, 2024).

The key elements that need to be addressed to raise a generation of talented, responsible STEM learners include integrated approaches to teaching and learning and effective teacher preparation (Kurup et al., 2019). Many authors have emphasized that prospective teachers should gain experience through practical STEM activities (Kurup et al., 2019; Özçakır Sümen & Çalışıcı, 2022; Sarı et al., 2020). It is well known that a quality STEM education can foster various behaviors, thanks to its strong problem-solving abilities through an interdisciplinary approach. One is gaining awareness of STEM practices (Sahito & Wassan, 2024; Sarı et al., 2020; Sarı et al., 2022). Awareness, defined as an individual's sensitive and conscious behavior towards his/her environment and himself/herself (Güleryüz, 2020), is an affective state that can be developed through the environments individuals encounter. Awareness has a positive impact on attitudes and behaviors (Sarı et al., 2020). In this context, it is believed that the practices carried out in the Interdisciplinary Science Teaching (IST) course can enhance prospective teachers' affective characteristics towards STEM education.

Despite the growing emphasis on interdisciplinary STEM education and teacher competencies, empirical evidence on how prospective teachers develop these competencies within the context of the IST course remains limited. Specifically, previous studies provide insufficient information on how interdisciplinary STEM practices are systematically integrated into teacher education and how such experiences contribute to both emotional outcomes (e.g., awareness) and professional competencies. Therefore, research is needed that examines how course-based practices, such as the IST course, support prospective teachers in developing their STEM awareness and related competencies.

This study aimed to investigate the effects of interdisciplinary practices implemented in an IST course on prospective teachers' STEM awareness and their thoughts. Accordingly, the overarching problem was as follows:

What is the effect of interdisciplinary practices implemented in the IST course on prospective teachers' STEM awareness and their thoughts about these practices?

The sub-problems are presented below.

1. Is there a statistically significant difference between prospective science teachers' pre-test and post-test STEM awareness scores?
2. Is there a statistically significant difference between prospective science teachers' pre-test and post-test STEM awareness positive and negative scores?
3. Are the pre-test and post-test STEM awareness total scores of prospective science teachers statistically significant regarding the following STEM practices (Yes-No)?
    3.1. Is there a statistically significant difference between the STEM awareness pre-test and post-test scores of those who do not follow STEM practices?
4. What are the thoughts of prospective science teachers regarding the course and the activities?

METHOD

Research Design

This study employs a mixed-methods research approach, combining quantitative and qualitative research methods. Accordingly, the quantitative phase was designed to investigate the effects of the practices implemented in the IST course on prospective teachers' STEM awareness, and the qualitative phase was designed to gather prospective science teachers' thoughts on the course and its activities. In the quantitative phase, a single-group pre-test/post-test research design, a type of experimental design, was employed. The qualitative approach was used to gain detailed insights into participants' experiences and to better understand the implementation process and context.

Study Group

The study group consisted of 66 prospective science teachers in their 4th year, majoring in Science Education at a state university in Türkiye. All participants were enrolled in the IST course during the implementation period and received the same instructional activities.

Participants were selected through convenience sampling because they were part of an intact group within the course context. The main inclusion criterion was enrolment in the IST course, ensuring that all participants had direct exposure to interdisciplinary STEM practices within a structured learning environment. This sampling approach is considered appropriate in studies focusing on accessible groups (Yıldırım & Şimşek, 2016) and is commonly used in course-based intervention research.

Implementation Process

The IST course aims to develop an interdisciplinary perspective in prospective science teachers and provide them with high-level experience by applying their acquired knowledge. It aims to make them aware of the integration of different scientific fields and the skills employed in this process, and to provide information on the importance of combining them to solve problems. Explanations regarding the procedures carried out in the course are below.

1. Information about the course content was given in the first week. The STEM Awareness Scale (pre-test) was administered.
2. The definition of interdisciplinary learning, the knowledge in different scientific fields (Science, Technology, Mathematics, Engineering), and the skills used in these fields, the effects of the combination of these fields were emphasized, and their reflections on education were discussed. In understanding the nature of interdisciplinary knowledge, it was discussed that real-life problems cannot be solved by a single discipline and that the importance of keeping them together in solving problems. Different learning approaches and practices in developing an

interdisciplinary perspective were examined and discussed within the science curriculum framework. STEM disciplines were examined. Knowledge and skills, new professions, the necessity and importance of STEM togetherness in solving real-life problems were discussed.

3. Activities were carried out in which prospective teachers could be active in developing their interdisciplinary knowledge and skills. It was aimed for them to get to know STEM disciplinary integration closely, to see its operation and the design process steps in its essence, to develop designs to solve a problem, to understand the tools and equipment that can be used in interdisciplinary education and their purposes of use with examples, and to prepare STEM lesson plans for science curriculum outcomes.
4. During the course, participants' thoughts about the general functioning were obtained weekly using the Self-Assessment form.
5. At the end of the lesson, the same researcher applied the STEM awareness scale (post-test). An open-ended survey was administered to gather feedback on the experiences gained during the lesson and their activities.

Data Collection Instruments

STEM Awareness Scale

In this study, the STEM Awareness Scale, developed by Buyruk and Korkmaz (2016), was used to assess prospective science teachers' awareness of STEM education. The scale is a five-point Likert-type scale comprising 17 items and two factors. Based on the analyses, the scale's validity was deemed sufficient. Cronbach's alpha values calculated for the original scale are: 0.927 for the total scale, 0.929 for the positive view factor, and 0.806 for the negative view factor. Cronbach's alpha values calculated for this study were 0.864 for the total scale, 0.870 for the positive view factor, and 0.705 for the negative view factor.

Self-Assessment Form

A self-assessment form was prepared for the participating prospective science teachers to evaluate themselves during the practices, and they were asked to provide written explanations of their thoughts about the course (see Table S.1). The researchers discussed and determined the suitability of the form's statements to the study's content. The statements were presented to the participants before the study to assess their comprehensibility.

Interdisciplinary Science Teaching Course Evaluation Questionnaire

At the end of the implementation, participants were asked to complete the Interdisciplinary Science Teaching Course Evaluation Questionnaire (ISTCEQ) (see Table S.1) to assess their experiences in the course and the activities they had carried out. The questionnaire aimed to encourage participants to reflect on and provide feedback on their learning throughout the practices. Before preparing the questions, international guidelines for course evaluation questionnaires were examined, and a total of 8 questions were developed. For reliability, the length of the questionnaire, the wording of the questionnaire instructions and questions, and the conditions of administration for validity, conditions such as the clarity and comprehensibility of the questions (a pilot study was made with prospective teachers with similar characteristics to the target group), answering time, and the absence of difficulty in the administration phase were taken into consideration and necessary measures were taken. In addition to the researchers, the questionnaire was reviewed by two faculty members, both experts in science education. Within the framework of these precautions, arrangements were made regarding the questions, and the final version of the questionnaire was finalized.

The survey questions include questions about participants' cognitive and affective behaviors. Accordingly, questions 1, 4, 5, and 7 have affective characteristics, while questions 2, 3, and 6 have cognitive characteristics. Question 8 is suggestive. Since this study examines changes and development in prospective teachers' affective characteristics towards STEM education resulting from practices carried out in the IST course, the results were interpreted by analyzing questions 1, 4, 5, 7, and 8 of the questionnaire.

Data Analysis

The data were analyzed according to the sub-problems prepared in accordance with the study's primary purpose. The first three problems were analyzed quantitatively, while the fourth was analyzed qualitatively.

Quantitative Analysis

Data analysis was conducted using SPSS software, based on data from 69 participants. Participants were required to have complete pre-test and post-test data and to fall within acceptable statistical ranges for normality. Cases that did not meet these criteria were excluded from further analysis.

In the first step of the analysis, the normality of the dataset used for comparative analyses was examined. For this purpose, z-scores, skewness and kurtosis values, and histogram curves were evaluated for each variable. Observations within the z-score range of ±3.29 were considered normal (Tabachnick & Fidell, 2013). The three participants outside this range were identified as outliers.

When the skewness and kurtosis coefficients, as well as the histogram patterns, were examined for these participants, it was confirmed that they continued to display outlier characteristics. In addition to these statistical indicators, the researcher's field notes indicated that these participants exhibited low levels of engagement and irregular participation during the course. Considering both statistical criteria and qualitative observations, these cases (4.3% of the total sample) were removed from the dataset to ensure the validity and interpretability of the findings. A data loss of less than 5% is considered acceptable and unlikely to distort the data structure (Tabachnick & Fidell, 2013). Consequently, all subsequent analyses were performed on the remaining 66 participants.

Qualitative Analysis

The written responses from 66 participants on the self-assessment form and the ISTCEQ were analyzed using a content analysis approach. In content analysis, similar data are grouped around specific concepts and themes, which are then organized and interpreted in a comprehensible way (Yıldırım & Şimşek, 2016).

The following steps were followed in the content analysis of the data.

1. After the raw data were read several times independently by the researchers at different times, codes were created for each question.
2. The researchers came together and checked whether there were differences between the codes. A tally was kept to check the consistency between the codes. The evaluation method was categorized as “Agreement” and “Disagreement” in the tally. The relevant data set was re-examined for the codes with differences of opinion, and a consensus was reached between the researchers. Frequency values were written according to the frequency of the codes.
3. Consensus and disagreement were calculated according to Miles and Huberman (1994). Consensus reliability: “Consensus / (Consensus + Disagreement) x 100”. After all these steps, the coding percentage was calculated for each question. According to Yıldırım and Şimşek (2016), reaching a reliability percentage of at least 70% indicates that the codes are reliable. The reliability percentages obtained in the study are presented in Table 1.

Table 1
ISTCEQ and self-assessment form concordance reliability values

Question No	Self-Assessment Form (%)	ISTCEQ (%)
Question 1	82.4	82.5
Question 2	92.8	-
Question 3	93.5	-
Question 4	88.2	79.1
Question 5	90.3	88.7
Question 7	-	87.8
Question 8	-	95.6

4. After the consistency between the codes was ensured, the codes with similar relationships in terms of meaning were combined under a specific category. These relationships were then explained under a higher-level theme. Some sample data for the core themes and categories are included in Table S.2. Upon examining the values in Table 1, it can be observed that the analyses are reliable, as the inter-coder agreement reliability values for each question exceed 70%.

FINDINGS

Results of STEM Awareness

The findings from comparing the STEM awareness scores of prospective science teachers before and after implementation, and from examining the distribution of the scores according to STEM follow-up, are as follows.

1. Is there a statistically significant difference between prospective science teachers' pre-test and post-test STEM awareness scores?

A dependent groups t-test was conducted to compare the mean STEM awareness scores of prospective teachers on the pre-test and post-test. The results are presented in Table 2.

Table 2
Dependent groups t-test results related to prospective teachers' STEM awareness pre-test-post-test score means

Measurement	N	χ	sd	df	t	p	Effect (d)
Pre-test	66	74.69	6.18	65	-7.209	.001*	-0.89
Post-test	66	79.68	4.87				

*p<0.05

Table 2 shows that there is a statistically significant difference between the participants' STEM awareness pre-test and post-test scores [$t_{(65)} = -7.209$, $p < .05$]. This finding indicates that the practices implemented in the IST course significantly increased participants' awareness. The effect size, calculated to indicate the magnitude of the significant difference ($d = -0.89$), indicates that this difference is large.

2. Is there a statistically significant difference between pre-test and post-test STEM awareness positive and negative scores of prospective science teachers?

The results of the dependent-groups t-test comparing prospective teachers' positive and negative pre-test-post-test mean scores for STEM awareness are presented in Table 3.

Table 3 reveals statistically significant differences between the participants' pre-test and post-test scores for positive and negative views of STEM awareness [$t_{(65)} = -7.087$, $p < .05$; $t_{(65)} = -2.945$, $p < .05$]. These findings suggest that the activities implemented in the course significantly increased participants' awareness of both the positive and negative aspects of STEM. The calculated effect sizes ($d = -0.87$, $d = 0.35$) indicate that the significant difference is large and small, respectively.

Table 3
Dependent groups t-test results related to prospective teachers' STEM awareness: Positive and negative test scores

Factor	Measurement	N	χ	sd	df	t	p	Effect (d)
Positive View	Pre-test	66	52.12	4.98	65	-7.087	.001*	-0.87
	Post-test	66	56.31	3.71				
Negative View	Pre-test	66	22.57	2.14	65	-2.945	.004*	0.35
	Post-test	66	23.36	1.93				

3. Are the pre-test-post-test STEM awareness total scores of prospective science teachers statistically significant regarding the following STEM practices (Yes-No)?

Table 4 presents the independent samples t-test results on whether there is a statistical difference between the mean STEM awareness pre-test and post-test scores of prospective teachers in terms of following STEM practices.

Table 4
Independent groups t-test results related to prospective teachers' STEM awareness

Measurement	Follow	N	χ	sd	df	t	p	Effect (d)
Pre-test	Yes	24	78.20	4.69	64	3.839	.001*	0.98
	No	42	72.69	6.07				
Post-test	Yes	33	80.84	4.16	64	1.988	.051	
	No	33	78.51	5.29				

*p<0.05

When the STEM awareness pre-test mean scores of participants regarding the following STEM practices were analyzed, a statistically significant difference was found between those who followed and those who did not [$t_{(64)}$ = 3.839, p < .05]. This finding indicates that individuals who follow STEM practices exhibit a significantly higher level of awareness than those who do not. The effect size, calculated as the magnitude of the significant difference (d = 0.98), indicates that this difference is large. In addition, the participants' post-test score averages did not reveal a statistically significant difference between those who followed and those who did not follow [$t_{(64)}$ = 1.988, p > .05].

Additionally, the results of the dependent groups t-test comparing the pre-test/post-test STEM awareness total mean scores of those who did not follow STEM practices are presented in Table 5.

Table 5
Dependent groups t-test results related to STEM awareness pre-test-post-test total scores

Measurement	N	χ	sd	df	t	p	Effect (d)
Pre-test	33	72.21	6.39	32	-5.741	.001*	-1.00
Post-test	33	78.51	5.29				

Table 5 shows that there is a statistically significant difference between the STEM awareness pre-test and post-test scores of participants who did not follow STEM practices, with the post-test score higher [$t_{(32)}$ = -5.741, p < .05]. This finding can be attributed to the impact of the practices in the IST course on participants' awareness, as those who did not follow the STEM practices during the course showed greater change in awareness. The calculated effect size (d = -1.00) indicates that this difference is large.

Findings on Prospective Teachers' Experiences in the STEM-Oriented Course

Participants' Expectations from a STEM-Oriented Course

The prospective teachers reported that they expected to gain STEM-oriented development from the IST course (see Table 6). In particular, they aimed to gain knowledge about what STEM means and the ability to apply STEM concepts. They also hoped to develop the ability to apply STEM principles

in their profession. Therefore, prospective teachers expect to gain theoretical and pedagogical knowledge about STEM and learn STEM practices.

Table 6
Prospective teachers' expectations from the IST course

Theme	Category	Code (f: number of text segments coded across participants)
STEM Focused Development	STEM Skill and Knowledge Development	Gaining knowledge about STEM (f:35), Learning STEM practices (f:19), Teaching STEM (f:18)
	Uses of STEM Knowledge	Using STEM-related knowledge in the profession (f:13), Benefit to the profession (f:6), The importance of STEM education (f:5), STEM daily life relationship (f:4)
Personal Development	Personal Benefit	Acquiring new knowledge (f:6), Getting information about the activity (f:6), Self-improvement (f:5), Using scientific process skills in daily life (f:2)
Effective Teaching	Science Teaching	Interactive lesson (f:5), Learning science content (f:2), Learning method (f:2), Integrating technology with the lesson (f:2)

The prospective teachers also aim to use their STEM-related knowledge and skills daily and professionally. This indicates that they seek to develop a deep understanding of STEM, acquire theoretical knowledge and skills, and integrate them into their professional lives.

Prospective teachers stated that they expect to undergo self-development by acquiring new knowledge in the course. In addition, they aim to actively use science process skills to solve daily-life problems. Finally, prospective teachers wanted to learn the content of science, learn new methods and techniques, and integrate technology into science education. In this context, prospective teachers need additional information and guidance to use STEM, an interdisciplinary knowledge, while teaching science.

Participants' Favorite Points about the IST Course

According to the self-assessment form data, the features that prospective teachers liked the most in the STEM-oriented course were the teaching process and the knowledge they gained (see Table 7). The fact that the course was activity-based, in that the prospective teachers were active, based on daily life problems, group work, and discussions, made them like the course. In addition to these, some prospective teachers found the discussion technique interesting and valued the way it was handled within the course content.

Table 7
Prospective teachers' favorite features of the course

Theme	Category	Code (f: number of text segments coded across participants)
Teaching Process	Teaching Materials	Watching video (f:24); Visuals (f:7)
	Teaching Activities	Activity (f:20)
	Teaching Techniques	Discussion (f:40), Group work (f:6), Making connections with daily life (f:6)
	Student-centered Structure	Active participation of the student (f:10)
Knowledge Construction	Presenting New Information	Learning new information (f:12)
	Creating an Understanding of Knowledge	Different perspective on information (f:7)

Another reason prospective teachers enjoyed the course was the selection of activities and materials used during instruction. The activities most favored by the prospective teachers in the IST course, along with their underlying reasons, are presented in Table 8.

The most popular activities were origami, design development, and bridge design. The reasons prospective teachers liked these activities were evaluated within six themes: cognition, affective, skill, activity structure, integration, and experience.

The majority of the prospective teachers liked the origami activity. According to prospective teachers, the origami activity supported cognitive (meaningful and easy learning), affective (interesting, fun, and intriguing), and psychomotor skills (developing hand skills and creating products) simultaneously. In addition, the interactive nature of the activity, its integration with STEM and art, its appeal to visual perception, and its association with the teaching profession were among the participants' opinions.

Table 8
Participants' favorite activities and reasons

Activity Name (n)	Theme	Code (n: the number of the participants)
Origami (n:44)	Cognition	Meaningful and easy learning (n:3)
	Affective	Fun (n:24); Interesting (n:4); Curiosity (n:1)
	Skill	Skill acquisition (n:6); Product creation (n:4); Calculation (n:2)
	Structure of the activity	Interactive (n:4); Visual perception (n:2)
	Integration	STEM relationship (n:7); Art relationship (n:3); Relationship with science (n:2); Integration into science teaching (n:2)
	Experience	Contribution to the teaching profession (n:3)
Design Development Activity (n:12)	Cognition	Reasoning (n:4)
	Affective	Fun (n:4)
	Activity Structure	Interaction (n:2)
	Skill	Product creation (n:4); Problem solving (n:2)
	Integration	STEM relationship (n:1)
	Experience	Contribution to the teaching profession (n:1)
Bridge Design (n:11)	Cognition	Reasoning (n:8); Learning new knowledge (n:1)
	Affective	Fun (n:4); Interesting (n:1)
	Skill	Use of engineering skills (n:2)
	Integration	STEM relationship (n:1)
5E Lesson Plan (n:4)	Cognition	Obtaining information (n:1)
	Affective	Interesting (n:1)
	Experience	Contribution to the teaching profession (n:3)
Augmented Reality App (n:4)	Cognition	Learning new knowledge (n:1)
	Affective	Product creation (n:1)
	Experience	Contribution to the teaching profession (n:2)
Video (n:4)	Cognition	Learning new knowledge (n:2)
	Affective	Fun (n:1)
Presentation (n:3)	Cognition	Learning new knowledge (n:2)
	Affective	Fun (n:1)
	Experience	Contribution to the teaching profession (n:1)
Web 2.0 tools (n:2)	Without reason	(n:0)
Coding (n:2)	Without reason	(n:0)

Design development and bridge design were among the most liked in the STEM-oriented course. The design development activity was especially preferred for skill-based reasons, such as problem-solving and product creation. Participants stated that producing ideas/solutions in collaboration with their peers during these activities was both enjoyable and instructive. On the other hand, the bridge design activity was mainly associated with cognitive themes (reasoning, acquiring new knowledge); it was also liked because it triggered technical thinking processes, such as engineering logic and cost-benefit analysis. The design development and bridge design activities also enabled prospective teachers to integrate different disciplines.

Augmented reality practices, 5E lesson plans, videos, presentations, Web 2.0 tools, and coding activities are among the least liked. A common feature of these activities is that they provide prospective teachers with experience related to the teaching profession. The participants stated that, thanks to these activities, they gained insights into the teaching process and developed plans for future professional practice.

When the reasons participants liked the activities were analyzed, it was determined that these reasons fell mainly under the theme of affective. In other words, for prospective teachers, the fact that the activities are fun, interesting, and engaging is a key reason for preference. Other reasons for liking the activities were categorized under themes such as cognition, skills, integration, experience, and the structure of the activity. As a result, activities that appeal to the senses, help learn new information, are practical, and include interdisciplinary connections are more liked.

Emotions, Thoughts, and Learnings Generated by the STEM-Oriented Course

Most participants reported positive feelings and thoughts about the IST course (see Table 9). The prospective teachers emphasized that they gained comprehensive information about the importance and necessity of STEM education and its role in the profession. Participants also thought that this course had both professional and personal effects. Many participants reported that after this course, they were able to approach problems from different perspectives and strive to find more innovative solutions. These findings demonstrate that the course is informative and features elements that provide multifaceted development to participants.

Table 9
Emotions and thoughts created by the course experience in participants

Theme	Category	Code (n: the number of the participants)
Positive Emotions and Thoughts	STEM Education	Acquiring STEM knowledge (n:17); Using STEM in profession (n:12); Understanding STEM better (n:10); Necessity of STEM education (n:5); Importance of STEM education (n:3); Relationship between Art and Science (n:2)
	Affective	Happiness (n:11); Self-confidence (n:9); Enjoyment (n:7); Excitement (n:6); Curiosity (n:5); Interdisciplinary awareness (n:2); Interest (n:2); Motivation (n:2); STEM positive attitude (n:1); Feeling lucky (n:1)
	Personal and Professional Development	Becoming a versatile individual (n:12); Different perspective on events (n:9); 21st century skills (n:5); Professional benefit (n:4); Personal benefit (n:3)
	Learning	Learning new information (n:2); Use of technological tools in education (n:2); Students' activity (n:2); Ease of learning (n:1); Importance of technological developments (n:1)
Negative Feelings and Thoughts	Learning	Inability to learn new information*(n:1)
	Course Content	Boring activity*(n:1)
	Affective	Low motivation*(n:1)

When participants' emotions aroused by the IST course were analyzed, they reported happiness after the course, increased curiosity about interdisciplinary knowledge, and greater self-confidence. Participants who expressed enjoyment during the lesson also felt excited while engaging in STEM activities.

Only two participants made negative evaluations about the course. One participant stated that repetitive practices, such as origami, were boring. The other participant stated that he had prior knowledge of STEM, so he could not learn anything new, and that this situation decreased his motivation. These views suggest that the course's repetitive structure may not have provided sufficient variety for some participants or that individual prior knowledge levels were not adequately taken into account.

The prospective teachers' thoughts about their learning from the IST course, as stated in the weekly self-assessments, are presented in Table 10.

Table 10
What prospective teachers learned from the course

Theme	Category	Code (f: number of text segments coded across participants)
STEM-oriented Education	STEM	STEM disciplines relationship (f:18); Importance of STEM (f:19); STEM (f:17); STEM education learning-teaching methods (f:4); STEM 5E integration (f:2)
Cognitive and Professional Development	The Nature of Invention	Characteristics of invention (f:12); Invention-STEM relationship (f:5); Connection of invention with physics (f:4); Integration of technological developments into the course (f:1)
	The Relationship between Science, Technology, and Engineering	Design process (f:14); Technology-engineering relationship (f:9); Science and technology relationship (f:5); Science and technology use and product (f:3)
	21st Century Skills	Importance of 21st century skills (f:5); Creative thinking (f:3); Importance of coding (f:2)

In the IST course, prospective teachers reported gaining knowledge related to their cognitive and professional development in STEM-focused education. The prospective teachers reported that they gained knowledge of the interdisciplinary relationships within STEM, the importance of STEM, learning and teaching methods for implementing STEM education, and the integration of STEM with the 5E learning model. In addition, although there were few participants, some reported gaining awareness of 21st-century skills, such as creative thinking and coding.

On the other hand, skill development is an important learning outcome that the prospective teachers did not emphasize in the self-assessment form but did mention in the ISTCEQ. In the ISTCEQ, participants thought that the theoretical knowledge they acquired in the IST course was reinforced through practice, positively impacting various skills. Problem-solving was the skill they thought they improved the most, followed by teamwork, information technology practice, critical thinking, creativity, and oral communication. In addition, prospective teachers emphasized that they also improved their professional skills, such as taking responsibility, entrepreneurship, and design development.

According to Table 11, most prospective teachers highlighted the positive factors that supported their skill development. However, a few participants (n = 6) stated that the course did not develop some of their skills. The reasons for these negative opinions included insufficient activities, lack of personal participation, and incompatibility with prior knowledge.

Active participation was the most frequently mentioned factor when classifying the elements believed to contribute to skill development. Prospective teachers thought they were actively involved in high-level cognitive processes such as problem-solving, design development, reasoning, and generating original ideas. These elements are among the factors that contribute to the development of participants' problem-solving and creativity/innovation skills.

External factors are the other factors considered adequate in their skill development. The participants stated that in-course practices, including activities, presentations, and the continuous use of information technology tools, directly contributed to their skill development. The prospective teachers found the course content presentations to be effective in developing their oral communication skills. At the same time, the activities were practical in developing their creativity/innovation, as well as their skills in using information technologies.

Another important factor in skill development is the cognitive category. Prospective teachers stated that they developed their skills in using information technologies by acquiring knowledge and using technological tools. They also said that their critical thinking skills improved thanks to gaining a multidimensional perspective on events.

Prospective teachers stated that the collaborative environment was the most effective factor in developing teamwork and oral communication skills. They noted that the constant interaction with

their peers during the course contributed to the development of these skills. In particular, sharing information through presentations and group activities helped prospective teachers improve their ability to collaborate and express themselves effectively.

The thoughts of prospective teachers regarding reflections on the knowledge and skills they acquired in the IST course in relation to their professional lives were obtained from the ISTCEQ. Almost all participants stated they would use the experiences they gained in this course professionally. Only one participant stated that they would not use it without giving a reason, and one said that they were undecided about whether to use it because they did not trust themself. A total of 7 participants mentioned that they would use these experiences if the subject matter were appropriate and their schools had sufficient materials. The remaining participants noted they would draw on these experiences to benefit their students. However, they also noted that the course's activities and the positive attitudes it fostered influenced their decision.

Table 11
Prospective teachers' reasons for the development of their skills after the IST course

Theme	Category	Code	Skill (n: the number of participants)
Positive Factors	Cognition	Knowledge acquisition	ITP(n:7); CI(n:3); CT(n:1); T(n:1); E(n:1)
		STEM knowledge acquisition	PS(n:1); ITP(n:1)
		Multifaceted perspective	CT(n:7); G(n:3); T(n:1)
		Better use of technological tools	ITP(n:4)
	Affective	Effort	PS(n:2); CI(n:1)
		Interest	T(n:1); ITP(n:1)
		Self-expression	OC(n:2)
		Gaining self-confidence	G(n:1)
		Responsibility	T(n:2); G(n:1)
		Self-regulation	CT(n:1)
	Cooperation	Interaction	T(n:10); OC(n:7); PS(n:3); G(n:2); CI(n:1)
		Adaptation to cooperation	T(n:1)
		Care of duty	R(n:1)
	External Factors	Effective lesson	CI(n:2); G(n:1)
		Presentation	OC(n:8); T(n:4); G(n:2); PS(n:1); E(n:1)
		Activity	CI(n:3); ITP(n:3); G(n:3); E(n:2); OC(n:1)
		Continuous use	ITP(n:3); T(n:2); PS(n:1); OC(n:1); E(n:1)
	Active Participation	Finding solutions	PS(n:7); CT(n:2); G(n:1)
		Design development	CI(n:10); PS(n:7); CT(n:4); G(n:2); ITP(n:2); T(n:1); OC(n:1)
		Reasoning	PS(n:2); CT(n:1); T(n:1); CI(n:1); G(n:1); E(n:1)
		Original idea	CI(n:4); CT(n:2); ITP(n:1)
	Education and Training Activity	Occupational use	CI(n:2); PS(n:1)
		Peer assessment	CT(n:4)
Negative Factors	External Factors	Lack of effectiveness	CI(n:2); CT(n:1); OC(n:1)
	Personal Factors	Insufficient participation	OC(n:2)
		Willingness to develop	OC(n:2; T(n:1); CI(n:1)
		Prior experience	PS(n:1); T(n:1); OC(n:1)
		Incompatibility in collaboration	T(n:3)

Note. Teamwork T; Problem Solving PS; Information Technology Applications ITA; Oral Communication OC; Creativity Innovation CI; Critical Thinking CT; General General; Entrepreneurship E; Responsibility abbreviated as R. Number (n) indicates the number of people.

Suggestions for the Development of the IST Course

The moments when participants were bored during the course and the suggestions they developed for these moments were not directly matched in the analysis. However, the holistic thematic analysis of the data reveals that specific reasons for boredom overlap with some of the suggestions. The data on the moments of boredom were collected through the weekly self-assessment form, and the tips for improving the course were collected through the weekly self-assessment and the ISTCEQ. The findings are presented in line with these thematic patterns.

Most participants attributed their boredom to the course's theoretical orientation, the long presentations, and the passive learning environment (see Table 12). In this context, the most frequently mentioned suggestion was to make the course more practice-oriented (see Table 13). The expressions "increasing applied activities" (n = 36) and "making STEM practices" (n = 10) were frequently emphasized in the forms. Prospective teachers stated they would like to see more activities each week that offer opportunities for experimentation, product creation, and active participation. In addition, some participants requested the inclusion of specific practices, such as Arduino, Web 2.0 tools, coding, and LEGO, in the course content. It was also frequently mentioned that technological tools, videos, and audio/visual materials should be used more actively in teaching the course. On the other hand, some participants stated that they experienced boredom based on their readiness level, such as insufficient knowledge or the challenging level of the subjects. For this reason, prospective teachers suggested reducing the content's intensity and extending the course's duration. Participants stated that when they felt passive during lessons, their interest decreased and they became disengaged. To solve this situation, prospective teachers suggested that the course be more interactive and participatory. Among the suggestions were prospective teachers' expectations regarding the course's infrastructure and equipment. Some participants stated that the tools and equipment to be used in the activities should be provided to them so that they can implement the practices more efficiently. In addition, suggestions such as establishing a STEM laboratory and introducing the course practices to a broader audience were also developed.

Table 12
Prospective teachers' evaluations of the most bored moments in the IST course

Theme	Category	Code (f: number of text segments coded across participants)
Teaching Process	Teaching Techniques	Theoretical expression (f:21), Discussion (f:2), Presentations (f:1), Much homework (f:1)
	Lack of Student Participation	Passivity of the student (f:15)
Student Readiness	Lack of Student Prior Knowledge	Insufficiency of knowledge (f:4), Perceived Topic Difficulty (f:1)

Table 13
Prospective teachers' suggestions for improving the IST course

Theme	Category	Code (f: number of text segments coded across participants)
Interdisciplinary Practices	In-class Practices	Increasing applied activity (f:36)
	Quality and Diversity of Activities	Hands-on activities (f:10); Diversification of activities (f:3); Interesting topics (f:2)
	STEM-oriented Practice	Making STEM practices (f:10); STEM lesson plan (f:3); Strengthening STEM education (f:1)
Learning Environment	Selection of Tools and Materials	Adding more audio/visual content (f:17); Use of video (f:7); Use of technological tools (f:3); Including technological developments (f:2)
	Curriculum	Grade level (f:3); Time extension (f:2); Content should be reduced (f:1)
	Homework	Less homework (f:1); More homework (f:1)
Ensuring Active Participation of the Student	Active Participation	Activating students (f:2)
	Interaction Must Increase	Being interactive (f:16); Teacher-student interaction should increase (f:1)
Infrastructure and Institutional Support	Material and Environmental Needs	Providing resources for activities (f:6); Establishing a STEM laboratory (f:2)
	Promotion and Sample Sharing	Introducing the practices (f:2)

DISCUSSION

This study aimed to investigate the impact of interdisciplinary practices in an IST course on prospective science teachers' STEM awareness and their thoughts on the course. The quantitative results show that the practices within the course scope significantly affected prospective teachers' STEM awareness ($p = .001$) and significantly increased their positive and negative STEM awareness ($p = .001$, $p = .004$). Studies in the literature indicate that increased awareness can be achieved through activities that engage students, such as reasoning, collaboration, and problem-solving (Özçakır Sümen & Çalışıcı, 2022; Sahito & Wassan, 2024). Affective features, such as practices within the course that foster active participation, interest, and curiosity, as well as the value attributed to the assigned tasks, can be considered positive indicators of awareness. This situation aligns with the participants' views. Findings regarding STEM awareness and the accompanying knowledge, skills, and professional development can be explained within the framework of STEM's interdisciplinary nature (Buyruk & Korkmaz, 2016; Mahlan et al., 2024), its encouragement of innovation, imagination, and creativity, and scientific thinking (Baharin et al., 2018).

According to another finding obtained prior to the lesson, STEM awareness among those who follow STEM practices is significantly different from that of those who do not. This is an expected situation. Affective components, including the social environment, interests, abilities, prior knowledge, experiences, attitudes, and beliefs, influence awareness. For a prospective teacher who closely follows scientific publications as an area of interest, having a high level of awareness and understanding of STEM fields is a fundamental requirement (Baran et al., 2020). Another finding is that the awareness of prospective teachers who did not follow STEM practices during the course changed significantly before and after they adopted these practices, underscoring the importance of interpreting the impact of the implemented practices. Following STEM activities from digital tools and printed sources has a positive impact on a person's affective aspects. However, considering that those who do not follow the activities are not interested in such practices, this finding can be explained by the practices carried out in the IST course. Providing prospective teachers with environments where they can follow STEM applications during their undergraduate education contributes to their career development by increasing their awareness of STEM (Aşılıoğlu & Yaman, 2020). Özçakır Sümen and Çalışıcı (2022) stated that awareness increases significantly with participation in STEM education.

The study's findings reveal that prospective teachers' expectations for the STEM course focus on developing a conceptual understanding of STEM and on gaining concrete skills in this field. Moreover, the prospective teachers expressed a need to learn how to apply the theoretical knowledge they gained about STEM in their daily lives. This need aligns with the primary goals of STEM education, which is to empower individuals to apply their knowledge to address social and environmental challenges (National Academies of Sciences, Engineering, & Medicine, 2025). Given the contribution of STEM education to solving complex problems (National Academies, 2006), it is natural that educational interventions would positively change prospective teachers' views of the process and raise their awareness.

Some participants in the study stated they expected to learn directly about science teaching in the IST course. Familiarity with the disciplinary nature of science subjects can be considered a reason for this. On the other hand, this finding indicates that the participants felt a need to view the science education content from a different perspective. Many studies in the literature indicate that STEM practices are not sufficiently integrated, especially interdisciplinary connections remain superficial, making it difficult for students to fully grasp the integration (Kelley & Knowles, 2016; Martín-Páez et al., 2019). The fact that activities such as bridge design, origami, and design development in the IST course are grounded in coherent, collaborative inquiry to encourage meaningful connections among the science, engineering, and mathematics disciplines may explain prospective teachers' efforts to make sense of STEM pedagogy (Kurup et al., 2019; Mahlan et al., 2024). The process-oriented

approach adopted in the IST course focused on developing prospective teachers' interdisciplinary thinking, problem-solving, and inquiry skills, without always translating these skills into a tangible product (Roehrig et al., 2012). Apart from these developments, it is reported that, despite high awareness, many candidates hold negative views of STEM content knowledge, teacher competencies, and conceptual change elements (Çelik et al., 2018). These key points indicate concerns about how STEM can be implemented in the classroom.

One of the elements that prospective teachers liked the most in the STEM-oriented course was the teaching techniques chosen. Interactive discussions, group work, and examples from daily life were the main factors that differentiated the IST course from other standard lectures. This finding aligns with the literature Timoštšuk et al. (2016), which indicates that student-centered teaching methods have a positive impact on attitudes towards the learning process. The student-centered, fundamental structure of STEM activities has a positive impact on learners' awareness, knowledge, and skill development (Sarı et al., 2020).

The second main element that increases the course's attractiveness is the hands-on activities and their affective impact on participants. The strong emphasis on affective factors such as fun, interest, and curiosity in participants' activity preferences can be explained by Pekrun's (2006) control-value theory. While activities such as bridge design offered participants a sense of 'control' over the materials, the goal of solving a problem and creating a tangible product can lead them to attribute a high cognitive and affective 'value' to these activities. This combination of control and value may have triggered positive academic emotions experienced in the course. This finding is consistent with the study conducted by Beymer et al. (2023) in informal STEM environments. In this study, participants' feelings of control during the activities were significantly associated with positive emotions, such as happiness and excitement. This finding shows that the extent to which participants are involved in the process and how much they can own the activity in STEM activities contributes to the emotional aspect of the learning process.

The fact that technology-oriented activities, such as augmented reality or Web 2.0 tools, received less attention in the research reveals a critical distinction regarding the role of technology in education. This may be due to how technology is used rather than the technology itself. While participants are passive 'consumers' when watching a video or examining a ready-made AR model, they are active 'producers' in the bridge design activity. This finding is consistent with constructivist learning principles and underscores the importance of preparing instructional content that encourages learners' creativity through technology integration, rather than merely presenting engaging visuals (Tang et al., 2022). Because mathematical calculations and scientific principles are used during the design process, it helps understand how knowledge from different disciplines works together (Zhong et al., 2024). It allows for the application of mathematical and scientific skills and creativity in design using existing materials. Thus, it contributes to the development of individuals who produce creative solutions with technology (Hemming, 2018). Creating an innovative product with technological design applications reinforces STEM awareness by transforming theoretical knowledge into practice through its multidisciplinary structure (Mahlan et al., 2024). It also creates innovations and engaging learning experiences that develop problem-solving, critical thinking, and collaboration skills (Mahlan et al., 2024; Rusydiyah et al., 2021).

The participants defined the course as a professional obligation and a learning experience that contributed to their personal development, enriched with positive emotions such as enjoyment, curiosity, and excitement. This finding suggests that the IST course effectively engages both cognitive and affective components (Pekrun, 2006; Rusydiyah et al., 2021). Indeed, one of the primary objectives of STEM education is to foster positive attitudes towards learning in individuals and to transform the learning process into a meaningful experience (National Research Council, 2014).

One of the most notable outcomes of the course is that participants reported developing high-level cognitive competencies, including problem-solving, critical thinking, and creativity, from an interdisciplinary perspective. It is believed that the tangible products created during the design and project development processes enhance participants' self-efficacy and self-confidence. During the project design process, students' confidence in their own abilities is supported through task-based work and peer learning (Samsudin et al., 2020). This is consistent with Bandura's vicarious experiences model. Prospective teachers with stronger self-efficacy are expected to be more willing to use STEM-based practices in the classroom (Margot & Kettler, 2019). These affective developments can be explained by the significant impact of design-oriented practices on prospective teachers' awareness and STEM skills.

In the study, most participants reported planning to draw on these experiences in their professional practice, believing that STEM practices would benefit their students. They also stated that the effects of the STEM activities they experienced had a decisive impact on their decisions. This finding reveals the potential of STEM education to shape professional orientations (Durmaz & Çelik Keser, 2024; Kelley & Knowles, 2016). It can be said that prospective teachers with increased STEM awareness better internalize the interdisciplinary nature of this approach and become more willing to implement it in their classrooms. On the other hand, the presence of a small number of participants who were undecided due to lack of self-confidence or lack of materials shows that it is not enough to provide only pedagogical content in teacher education; institutional elements such as supportive structures and access to physical resources that will reinforce self-efficacy beliefs should be provided simultaneously (Johnson & Czerniak, 2023; Margot & Kettler, 2019). It is stated that the support of managers and colleagues in implementing STEM applications, as well as the provision of materials and resources, can overcome obstacles in the process (Durmaz & Çelik Keser, 2024). These statements support the thoughts of participants who are experiencing hesitation.

The prospective teachers stated that peer interaction-based practices, such as group work and presentations in the course, led to significant improvements in their teamwork and oral communication skills. Such learning environments support not only cognitive but also social development of individuals (Vygotsky, 1978). In multidisciplinary structures such as STEM, effective communication and collaborative working skills play a critical role in the efficiency of the teaching process (Margot & Kettler, 2019; Sheth & Pathak, 2023). Structural equation modeling studies have shown that the variable with the strongest link between teachers' attitudes towards STEM and activity preferences is "perception of collaboration" e.g., Lai (2021), confirming the central role of collaborative environments in shaping attitudes.

The findings point to the interaction of three key elements that trigger skill development in participants: the participant's action, the environment's design, and the structure that combines mental processes. This model can be achieved through active participation. However, participation alone is insufficient; the participants' statements indicate that structured learning experiences also play a significant role in shaping learning. The course activities, tools, and teaching methods helped participants manage complex tasks. A quality STEM education should be structured in a student-centered way that encourages active participation and generates systematic solutions to real-world problems (Baharin et al., 2018). Another important element that enhanced their skill development was meaningful cognitive learning.

The findings of this study suggest that more hands-on activities are needed to enrich the learning experience in STEM-focused courses. The literature also emphasizes that interdisciplinary integration should be explicitly incorporated for STEM practices to be effective (Kurup et al., 2019; Martín-Páez et al., 2019; Özçakır Sümen & Çalışıcı, 2022; Sarı et al., 2020). It is essential to design learning activities that integrate the disciplines of science, technology, engineering, and mathematics around a unified problem-solving process (Kelley & Knowles, 2016; Kurup et al., 2021).

Participants requested interactive learning environments in STEM-oriented courses. This suggestion highlights the importance of a learning process that incorporates group work, discussions, and presentations. In this context, collaborative activities support the development of social skills and foster positive attitudes towards learning (Schmidt et al., 2018). Lai (2021) found that teachers' attitudes towards STEM activities are closely related to their perceptions of collaboration and that such environments contribute positively to the learning process.

Participants' criticisms of the content's intensity and lack of prior knowledge may indicate that the IST course is cognitively taxing for some. This situation reveals the importance of structured and prior knowledge-based modular instructional designs (Tang et al., 2022). To conduct the course more effectively, participants suggested reducing content density, extending the course duration, and adapting activities to suit the grade level. Additionally, the lack of infrastructure and institutional support constitutes a significant obstacle to the sustainability of STEM practices. In this context, it is recommended that teachers improve their ability to adapt practices according to grade level, instructional time, and available resources Roehrig et al. (2012) and that schools reorganize their structures and processes to increase opportunities for interdisciplinary collaboration (Johnson & Czerniak, 2023).

CONCLUSIONS AND SUGGESTIONS

The findings of this study revealed that the STEM awareness of the prospective teachers who participated in the IST course increased significantly by the end of the course. The statements of prospective teachers suggest that the STEM course not only provided conceptual knowledge but also fostered multidimensional skills, such as interdisciplinary thinking, problem-solving, and collaboration. Participants' reflections further indicate that activity-based and interactive learning environments were perceived as particularly effective in supporting both cognitive and affective engagement.

Based on these findings, several implications for practice can be suggested. First, interdisciplinary STEM practices that emphasize active participation and hands-on learning may be more systematically integrated into teacher education programs. Second, designing learning environments that include collaborative activities, real-life problem-solving tasks, and diverse instructional materials may enhance both engagement and skill development. In addition, reducing overly theoretical content and increasing the diversity and frequency of practical activities may improve the effectiveness of such courses, as indicated by participant feedback.

The study has some limitations that should be considered when interpreting the findings. First, although participants produced products through activities such as origami and bridge design, they expressed their solutions only on paper during the design development process. The fact that this was the first implementation of the IST course at the university level, along with limited access to technological resources, may have constrained the development of more concrete, technology-supported products. Secondly, the new and intensive nature of the course content may have created challenges in time management, limiting prospective teachers' opportunities to deepen their learning. This situation may have affected the extent to which participants engaged with multidimensional (cognitive, affective, and behavioral) aspects of the learning process.

In line with these limitations, several directions for future research are suggested. Future studies may employ complementary data collection tools, such as observations, reflective journals, and portfolios, to better capture the development of complex skills, such as collaboration and problem-solving. In addition, incorporating technological tools such as Arduino, LEGO, and coding applications can provide more opportunities for participants to engage in hands-on, product-oriented learning experiences. Furthermore, future research may explore different dimensions of STEM practices in teacher education contexts, including their impact on various cognitive, affective, and professional

outcomes. Longitudinal studies may also provide a deeper understanding of how interdisciplinary STEM practices influence teacher development over time.

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APPENDIX

Table S.1.
Alignment of Interview Themes with Weekly Self-Assessment and Course Evaluation Forms

Themes Derived from Participant Responses	Self-Assessment Form	Interdisciplinary Science Teaching Course Evaluation Questionnaire
Prospective teachers' expectations from a STEM-focused course	1. What do I expect from this course?	–
Most appreciated aspects of the STEM-focused course	2. The moments I enjoyed most in this course?	5. Which activity/activities did you like the most in this course? Please explain the reasons for your answer.
Emotions, thoughts, and learnings experienced through the STEM-focused course	4. What did I learn from this course?	1. What feelings and thoughts did the experiences in this course evoke in you? 4. Do you think you will be able to use the experiences you gained in this course in your future teaching career? Please explain. 7-a. Which skills were improved through the activities in this course? Please rank them from 1 (most improved) to 8 (least improved). 7-b. Please explain the reasons for your ranking.
Suggestions for improving the STEM-focused course	3. The moments I felt most bored in this course? 5. My suggestions for how this course could be conducted.	8. What are your suggestions for improving this course?

Table S.2.
Sample Participant Quotes Illustrating Some Key Themes

Theme-Category-Code	Quote (Participant No)
STEM-Focused Development- STEM Skill and Knowledge Development- Gaining knowledge about STEM	"As the word 'interdisciplinary' suggests, I want to learn about the relationships among the subjects in STEM and understand them better." P-12
Personal Development- Personal Benefit- Getting information about the activity	"I expect to learn about different activities and teaching styles that can be used in the classroom." P-31
Teaching Process- Teaching Materials- Watching videos	"I most enjoyed the sessions supported with video content. " P-53
Knowledge Construction- Presenting New Information- Learning new information	"I enjoyed the moments when unfamiliar perspectives were introduced and I learned new scientific knowledge. " P-67
Origami- Affective- Fun	"Origami was really fun. I'm planning to try it with my students in the future." P-2
Design Development Activity- Cognition-Reasoning	"Designing a project helped us think broadly. It was great to consider new solutions and try to realize them. " P-8
Positive Emotions and Thoughts- Personal and Professional Development- Becoming a versatile individual	"It helped me become a more creative, efficient, skilled, and confident person." P-7
STEM-oriented Education -STEM- STEM disciplines relationship	"I learned how the theoretical knowledge from physics could be applied in different areas. I also realized that theory alone is not enough and we need to benefit from multiple fields and cultural knowledge as well." P-23
Positive Factors- Cooperation-Interaction	"As in every activity, I believe I developed my teamwork skills through sharing knowledge."P-9
Interdisciplinary Applications-In-class Applications- Increasing applied activity	There can be hands-on parts of the course in every topic."P-9