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Exploring Science Teachers' Views on Design Thinking Oriented STEM Education Practices

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***Abstract*:** This study aims to explore science teachers' perspectives on the implementation of STEM (Science, Technology, Engineering, and Mathematics) applications through a Design Thinking (DT) approach. Employing a qualitative case study design, semi-structured interviews were conducted with 11 science teachers selected via maximum variation sampling, a purposive sampling strategy. Data were analyzed through content analysis. The findings reveal that science teachers generally perceived DT-based STEM applications positively, particularly in terms of enhancing instructional effectiveness. Participants reported that these practices supported both their professional and personal growth, fostered greater classroom interaction, and improved student motivation. Additionally, the teachers emphasized a strong connection between STEM activities and the development of computational thinking skills—especially in fostering algorithmic thinking, problem-solving, and systematic analysis. Despite these benefits, several implementation challenges were noted, including time constraints, curriculum overload, limited resources, classroom management issues, and occasional lack of student engagement. Overall, the study concludes that the design-based thinking approach serves an integrative function in embedding creative and computational thinking within STEM education, offering multifaceted benefits for both students and educators.

***Keywords**:* STEM education, Design-based thinking, and Science teachers.

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Introduction

The social, technological, and economic transformations of the 21st century demand not only that individuals possess knowledge, but also that they use this knowledge creatively, integrate it with problem-solving skills, and generate products that add value to society. Accordingly, one of the fundamental goals of education systems is to raise students as analytically, creatively, and cognitively equipped individuals. STEM education is viewed as a key vehicle for achieving this goal, aiming to cultivate interdisciplinary thinking, critical analysis, productivity, and digital competence among students (Wingard et al., 2022). However, the effective implementation of STEM requires the development of pedagogical approaches that are participatory, inclusive, transformative, and aligned with contemporary needs.

In this context, the Design Thinking (DT) approach adds a creative, solution-focused, and student-centered dimension to STEM education, offering a structure that deepens the learning process both cognitively and affectively (Goldman et al., 2014; Wu et al., 2019). Emphasizing elements such as empathy, iterative prototyping, and the framing of real-world problems, DT stands out as a strong instructional framework that supports both creative and cognitive development (Goldman et al., 2014; Elwood & Jordan, 2022). Research has shown that DT enhances students' creative tendencies and innovation capacities while strengthening their engagement with complex and socially meaningful problems (He et al., 2023; Mahil, 2016; Frear & Fillip, 2019). Furthermore, DT has been associated with the development of STEM-related competencies across a wide range of students, from early childhood to adolescence (Yalçın & Erden, 2021; Ho, 2025; Wingard et al., 2022).

The design thinking approach can also be utilized to facilitate collaboration among teachers from different disciplines, owing to its collaborative and interdisciplinary nature. In this context, the DT approach has the potential to serve as a convergence point for integrating all disciplines in STEM education. Additionally, it can function as a problem-solving method to tackle STEM challenges (Öztürk, 2020). In this regard, it is important to reveal science teachers' knowledge, emotions, thoughts, and experiences related to STEM applications based on the design-based thinking approach. Teachers' perceptions of DT-based STEM processes, their classroom reflections, the challenges they encounter, and their views on the impact of these practices on students will provide significant insights into the scalability of such applications. Accordingly, this study aims to analyze in detail science teachers' views on STEM applications implemented through the design-based thinking approach. It is anticipated that the findings from this research will contribute to the dissemination of DT- and STEM-based practices in education and help shape teacher professional development programs.

Methodology

This research is a qualitative study aimed at examining science teachers' views on STEM applications implemented through the design-based thinking approach in depth. The case study method was chosen as the research design. Within the scope of the study, the case study method, one of the qualitative research methods, was employed. A case study is a qualitative research approach that enables in-depth examination of a subject or phenomenon within a certain time frame (Creswell, 2013). This feature was influential in choosing the case study method for this research. Additionally, the case study contributes methodologically to the research by offering the opportunity to examine specific, multiple, or thematic events in depth.

Working Group

The study group consisted of 11 science teachers selected from various provinces, representing a range of professional backgrounds and levels of expertise. Their teaching experience spans between 10 and 20 years. Notably, many participants have served as coordinators or trainers in TÜBİTAK-supported projects and have been actively involved in STEM-based educational practices. For confidentiality, each participant was assigned a code (e.g., P1, P2, P3, etc.).

Table 1. Demographics of the participants

Participant Code	**Gender**	**Place of Duty**	**Experience (Years)**	**STEM Experience**	**Type of Interview**
Participant Code	Gender	Institution	Experience (Years)	STEM Experience	Interview Type
P1	Female	Public Middle School	16	10 years	Online
P2	Female	BILSEM	12	5 years	Face-to-face
P3	Male	Public Middle School	20	8 years	Online
P4	Female	BILSEM	14	7 years	Face-to-face
P5	Male	Public Middle School	15	5 years	Online
P6	Female	Public Middle School	13	4 years	Online
P7	Male	BILSEM	17	10 years	Online
P8	Female	Public Middle School	18	6 years	Face-to-face
P9	Female	BILSEM	16	9 years	Online
P10	Male	Public Middle School	11	3 years	Face-to-face
P 11	Female	BILSEM	19	10 years	Online

Upon examining Table 1, it is observed that the professional experience of the participating science teachers ranges between 11 and 20 years. The institutions where participants work include public middle schools and science and art centers, which is significant for ensuring teacher diversity. The duration of experience with STEM applications ranges from 3 to 10 years. This variation in participants' levels of experience with the subject allows for the collection of richer and more multidimensional data. Additionally, 7 of the interviews were conducted online, while 4 were conducted face-to-face, reflecting a flexible approach to data collection. The gender distribution of the participants indicates a predominance of female teachers. This diversity contributes to gathering teacher opinions from different contexts and enhances the validity of the findings.

Regarding adherence to ethical principles, participants' identities were kept confidential, and the data were used solely for scientific purposes. Voluntary participation forms were obtained from the participants, and all data were processed in accordance with confidentiality principles.

Data Collection Tool

The data for this study were collected using a semi-structured interview form developed by the researcher and structured based on the opinions of field experts. The interview form consists of 13 open-ended questions focusing on STEM applications based on the design-based thinking approach. These questions were structured around five main themes to reveal participants' general evaluations of the applications, their relationship with computational thinking, their contributions to creative thinking, the challenges encountered during the process, and the impacts on classroom practices and personal development. Interviews were conducted both online and face-to-face, with each interview lasting approximately 30 to 45 minutes. Audio recordings were made with participants' consent and were later transcribed in detail. Below are the 13 different interview questions addressed under 5 main themes in the study:

Table 2. Interview Questions

Main Theme	Interview Questions
General Questions about Design-Based Thinking	What are your thoughts on STEM education applications based on the design-based thinking approach? Please explain. (Positive aspects, negative aspects, evaluation from the perspectives of teachers and students)
	How did you feel while implementing STEM education applications based on the design-based thinking approach in your lessons? Please explain.
Questions about Computational Thinking	Thinking about the STEM applications you have previously implemented, how do you use STEM applications to solve a problem during STEM activities? Please explain.
	How frequently do you use different strategies in your lessons? Do you prefer strategies that you have not used before in the problem-solving process? Please explain.
	What are your thoughts on the role of computational thinking in STEM education applications? What do you think about the role of STEM education applications in helping students develop computational thinking skills? Do STEM applications raise awareness of computational thinking? Please explain.
Questions about Creative Thinking	Are STEM activities implemented through the design-based thinking approach effective in developing creative solutions? At which stage of design-based thinking do you think it contributes? How does it contribute? Please explain.
	How do you encourage children to generate original ideas during the activities you conduct in your classroom? Please explain.
	Do you think STEM education applications affect or encourage creative thinking? Please explain.
Benefits of Design-Based Thinking STEM Applications for Students	Do you think STEM activities implemented through the design-based thinking approach affect students' perspectives on other subjects? Please explain.
	What challenges have you encountered in these applications? What challenges have your students faced? What solutions did you implement for these challenges? Please explain.
Feedback on Design-Based Thinking STEM Applications	Do you think STEM applications implemented through the design-based thinking approach contribute to your personal development and classroom practices? Please explain.
	How free or constrained do you feel during STEM activities implemented through the design-based thinking approach? Please explain.
	What suggestions do you have for improving STEM activities implemented through the design-based thinking approach? Please explain.

Data Analysis

The collected data were analyzed using content analysis techniques. Content analysis is a qualitative data analysis method aimed at systematically dividing data into meaningful categories by coding texts according to predetermined rules (Büyüköztürk et al., 2012). In the content analysis process, the interview transcripts were first carefully read to identify meaningful expressions, and appropriate codes were assigned to these expressions. For example, a participant's statement, "I observed that students developed different perspectives and contributed with original ideas during the activity" (P3), was associated with the code "development of original ideas" under the creative thinking theme. Subsequently, similar codes were grouped to form sub-themes and main themes. To enhance the reliability of coding, a comparison was made with a second researcher, and consensus was reached on any discrepancies. The researcher ensured that participants were free to express their views during the interviews and made efforts to avoid leading questions. To minimize bias during the analysis process, coding was performed independently at least twice, and verification was ensured through comparisons between researchers. Teachers were included in different codes by giving more than one answer.

Reliability and Validity

Various measures were taken to ensure the reliability of the research. First, the semi-structured interview form used as the data collection tool was reviewed and finalized based on the opinions of three field experts. Researcher triangulation was employed during the data analysis process, increasing consistency by having multiple researchers perform coding and compare interpretations. To support the accuracy and transparency of the findings, direct quotes from participants' statements were included. Additionally, to ensure internal validity, the data were described in detail and contextually; and to support external validity, participants with different demographic characteristics were included in the study based on the principle of maximum variation sampling.

Furthermore, to determine inter-coder reliability, coding conducted by two independent researchers was compared, and the agreement index was calculated using the formula suggested by Miles and Huberman (1994) (Agreement / [Agreement + Disagreement]). As a result of this calculation, an agreement rate of 90% was achieved, which is considered a high level of reliability for qualitative research. Data on which researchers disagreed were discussed and necessary adjustments were made.

Findings

During the research process, 13 questions were asked across five different categories. These included general questions, questions related to computational thinking, questions related to creative thinking, questions regarding the benefits of STEM applications for students, and questions about STEM studies implemented through the design-based thinking approach.

In the first part of the research, the sub-themes and codes related to the General Questions about Design-Based Thinking are presented in the table. The content analysis of the teachers' responses to the question "What are your thoughts on STEM education applications based on the design-based thinking approach? Please explain. (Positive aspects, negative aspects, evaluation from the perspectives of teachers and students)" is provided in Table 3.

Table 3. Teachers' Views on STEM Education Applications Based on the Design-Based Thinking Approach

Theme	**Code**	**n**	**Participant**
Positive Views	Creativity	6	P1, P10, P4, P6, P8, P9
	Problem Solving	4	P2, P6, P8, P9
	Scientific Thinking	4	P2, P6, P8, P9
	Interdisciplinary Learning	3	P1, P2, P9
	21st Century Skills	4	P11, P3, P6, P8
	Student-Centered Learning	5	P11, P2, P4, P8, P9
Negative Views	Time Management Issues	7	P1, P10, P11, P2, P4, P6, P8
	Lack of Infrastructure	4	P10, P11, P4, P5
	Teacher Competency	4	P10, P11, P3, P6
	Classroom Management Difficulty	3	P10, P11, P3
	Evaluation Challenges	3	P11, P6, P7

	Exam Pressure	2	P10, P11

Upon examining Table 3, the statements of the teachers regarding STEM applications based on the design-based thinking (DBT) approach were classified under the themes of positive views and negative views. Under the positive views theme, a total of six different codes were developed by the participants. Particularly, there was an emphasis on high-level skills such as creativity (n=6), problem-solving (n=4), scientific thinking (n=4), and student-centered learning (n=5). This demonstrates that the applications possess a structure that enhances cognitive depth and student engagement. Sample statements are provided below:
P1: "Their creativity is developing, and they're coming up with original ideas."
P9: "Their analytical thinking has improved, and we're progressing with scientific foundations."
P4: "There was more participation in class, and students worked eagerly."

Additionally, participants indicated that they acquired gains in line with contemporary educational approaches, such as 21st-century skills (n=4) and interdisciplinary learning (n=3). On the other hand, the negative views predominantly highlighted structural challenges of the applications. The most frequently mentioned issue was time management (n=7). Participants expressed concerns about the insufficient planning of time for the activities. Furthermore, issues related to the learning environment, such as lack of infrastructure (n=4), teacher competency (n=4), and classroom management difficulties (n=3), were also emphasized. Sample statements are provided below:
P1: "The activities take a lot of time, and we struggle to keep up with the schedule."
P11: "In crowded classes, it's very difficult to attend to all groups."
P6: "I don't have enough experience with such activities; we need training."

In addition, systemic issues such as evaluation challenges (n=3) and exam pressure (n=2) were also mentioned by participants. These findings indicate that although the applications are found beneficial, the educational system is not yet fully prepared for such innovative approaches.

The content analysis of teachers' responses to the question "How did you feel while implementing STEM education applications based on the design-based thinking approach in your lessons? Please explain." is presented in Table 4.

Table 4. Teachers' Views on Their Feelings While Implementing STEM Education Applications Based on the Design-Based Thinking Approach

Theme	Code	n	Participant
Positive Emotions	Excitement	4	P1, P2, P6, P9
	Success	4	P1, P11, P7, P9
	Learner Guidance Role	3	P2, P8, P9
	Increased Motivation	6	P1, P11, P4, P6, P7, P9
Challenging Emotions	Stress and Time Pressure	5	P1, P10, P11, P3, P5
	Feelings of Inadequacy	4	P10, P11, P3, P5
	Lack of Interest	2	P11, P5

Upon examining Table 4, it is seen that the emotions experienced by teachers during STEM applications based on the design-based thinking (DBT) approach were categorized into two main themes: positive emotions and challenging emotions. Under the positive emotions theme, four key codes stand out. In particular, the codes of increased motivation (n=6), success (n=4), and excitement (n=4) demonstrate that the applications created a positive atmosphere for the teachers. Sample statements are provided below:
P6: "As participation increased, my motivation also increased."
P1: "Creating with the students excited me a lot."

Additionally, the learner guidance role (n=3) code indicates that teachers internalized their role not just as knowledge transmitters but also as guides in the learning process.

In the challenging emotions theme, teachers highlighted the difficulties encountered during the implementation process. Specifically, the codes of stress and time pressure (n=5) and feelings of inadequacy (n=4) reflect that teachers faced various systemic and personal challenges while implementing these applications. This indicates that while teachers want to adopt innovative approaches, some external and internal factors make this process more difficult. Sample statements are provided below:

P3: "I had difficulty implementing the activities as planned; time was insufficient."

P11: "While trying to implement activities with students, I felt I wasn't sufficiently equipped."

Furthermore, the code of lack of interest (n=2) shows that DBT-based applications do not always generate the same level of interest among all students, which can create an emotional burden for teachers.

The sub-themes and codes for the second main theme, Questions about Computational Thinking, are presented next. The content analysis of teachers' responses to the question "Thinking about the STEM applications you have previously implemented; how do you use STEM applications to solve a problem during STEM activities? Please explain." is presented in Table 5.

Table 5. Teachers' Views on the Applications Used to Solve Problems during STEM Education Applications Based on the Design-Based Thinking Approach

Theme	Code	n	Participant
Problem Solving	Problem Definition	5	P1, P11, P2, P4, P7
	Ideation	5	P1, P11, P3, P4, P7
	Prototyping	6	P1, P11, P3, P4, P7, P9
	Interdisciplinary Integration	8	P1, P10, P2, P4, P5, P7, P8, P9

Upon examining Table 5, it is observed that teachers' views on the problem-solving process during STEM applications based on the design-based thinking approach were categorized under four main codes: "problem definition" (n=5), "ideation" (n=5), "prototyping" (n=6), and "interdisciplinary integration" (n=8). Sample statements are provided below:

P1: "After designing and creating a prototype, we gather feedback from other students."

P13: "As a group, we conduct brainstorming and division of tasks to develop solution proposals."

The content analysis of teachers' responses to the question "How frequently do you use different strategies in your lessons? Do you prefer strategies that you have not used before in the problem-solving process? Please explain." is presented in Table 6.

Table 6. Teachers' Views on the Applications Used When Preferring Different Strategies During STEM Education Applications Based on the Design-Based Thinking Approach

Theme	Code	n	Participant
Strategy Preference	Student Needs	3	P11, P5, P8
	Methodological Flexibility	7	P1, P10, P11, P6, P7, P8, P9
	Project-Based Applications	3	P11, P3, P5

Upon examining Table 6, it is seen that teachers' views were expressed under the "strategy preference" theme with the codes of student needs (n=3), methodological flexibility (n=7), and project-based applications (n=3). The codes indicate that teachers identified different strategies based on students' needs during design-based thinking STEM applications,

emphasized the importance of methodological diversity, and frequently incorporated project-based activities in their practices. Sample statements are provided below:
P1: "Strategies I haven't used before keep the teaching process fresh and dynamic."
P11: "I try new strategies based on students' needs."

The content analysis of teachers' responses to the question "What are your thoughts on the role of computational thinking in STEM education applications? What do you think about the role of STEM education applications in helping students develop computational thinking skills? Do STEM applications raise awareness of computational thinking? Please explain." is presented in Table 7.

Table 7. Teachers' Views on the Role of STEM in Computational Thinking during STEM Applications Based on the Design-Based Thinking Approach

Theme	Code	n	Participant
The Role of STEM in Computational Thinking	Algorithmic Thinking	4	P1, P10, P6, P9
	Decomposing Problems	4	P1, P11, P4, P9
	Interdisciplinary Alignment	4	P10, P2, P4, P9
	Awareness Gained	8	P1, P10, P11, P4, P5, P6, P8, P9

Upon examining Table 7, it is seen that teachers' views were expressed under the theme of "the role of STEM in computational thinking" with the codes of algorithmic thinking (n=4), decomposing problems (n=4), interdisciplinary alignment (n=4), and awareness gained (n=8). Looking at the codes, it is evident that teachers generally agreed that STEM applications contributed to computational thinking, with a particular emphasis on expressions highlighting awareness gained. Sample statements are provided below:
P9: "Computational thinking helps develop the ability to break down and analyze problems."
P10: "Computational thinking and STEM complement each other."

The sub-themes and codes for the third main theme, Questions about Creative Thinking, are presented next. The content analysis of teachers' responses to the question "Are STEM activities implemented through the design-based thinking approach effective in developing creative solutions? At which stage of design-based thinking do you think it contributes? How does it contribute? Please explain." is presented in Table 8.

Table 8. Teachers' Views on the Contributions of Creative Thinking during STEM Applications Based on the Design-Based Thinking Approach

Theme	Code	n	Participant
Contributions of Creative Thinking	Ideation	7	P1, P2, P3, P5, P6, P7, P8
	Prototyping	6	P2, P3, P5, P6, P7, P9
	Empathy	5	P1, P3, P8, P9, P10

Upon examining Table 8, it is seen that teachers' views were expressed under the theme of "contributions of creative thinking" with the codes of ideation (n=7), prototyping (n=6), and empathy (n=5). Looking at the codes, it is clear that teachers expressed that design-based thinking STEM applications supported creative thinking processes, with the contribution being particularly strongly felt during the ideation stage. Sample statements are provided below:
P8: "The processes of empathizing and defining the problem lay the groundwork for producing creative solutions."
P7: "During the ideation stage, students discover different solution pathways."

The content analysis of teachers' responses to the question "How do you encourage children to generate original ideas during the activities you conduct in your classroom? Please explain." is presented in Table 9.

Table 9. Teachers' Views on the Contributions of Creative Thinking in Classroom Practices during STEM Applications Based on the Design-Based Thinking Approach

Theme	Code	n	Participant
Creativity in Classroom Practices	Creating a Free Environment	5	P1, P3, P4, P7, P11
	Brainstorming and Feedback	4	P3, P6, P7, P8

Table 10. Teachers' Views on the Impact of STEM on Creative Thinking during STEM Applications Based on the Design-Based Thinking Approach

Theme	Code	n	Participant
Impact of STEM on Creative Thinking	Interdisciplinary Creativity	5	P1, P2, P5, P9, P11
	Problem-Based Approach	7	P3, P4, P5, P6, P7, P9, P10
	Collaborative Learning	3	P6, P9, P11

Upon examining Table 10, it is seen that teachers' views were expressed under the theme of "impact of STEM on creative thinking" with the codes of interdisciplinary creativity (n=5), problem-based approach (n=7), and collaborative learning (n=3). The codes indicate that teachers believe STEM applications encourage creative thinking, especially through problem-solving processes and collaborative activities that contribute to the development of creative ideas. Sample statements are provided below:

P6: "STEM offers an open-ended process, providing students with plenty of opportunities to develop ideas."

P11: "I observe an increase in students' confidence when they work in groups."

Table 11. Teachers' Views on the Contributions of Design-Based Thinking STEM Applications to Students

Theme	Code	n	Participant
Contributions to Students	Increased Interdisciplinary Interest	1	P11
	Creativity	2	P1, P9
	Communication	2	P8, P9

Upon examining Table 11, it is seen that teachers' views were expressed under the theme of "contributions to students" with the codes of increased interdisciplinary interest (n=1), creativity (n=2), and communication (n=2). The codes indicate that teachers believe STEM activities based on the design-based thinking approach enhance students' interest in different subjects, develop their creativity, and positively impact their communication skills. Sample statements are provided below:

P11: "It fosters a positive attitude towards subjects like mathematics and makes learning easier."

P8: "The design process improves students' skills in presenting ideas and collaborating."

Table 12. Teachers' Views on Challenges and Solution Suggestions during Design-Based Thinking STEM Applications

Theme	Code	n	Participant
Challenges Encountered	Time Constraints	6	P1, P2, P4, P6, P7, P11
	Lack of Materials	6	P1, P3, P4, P5, P6, P11
	Student Motivation	5	P1, P3, P6, P9, P10
	Classroom Management Difficulty	4	P3, P6, P10, P11
Solution Suggestions	Use of Low-Cost Alternatives	3	P1, P4, P9
	Student Roles and Group Support	2	P1, P8

	Individual Support and Flexible Planning	1	P8

Upon examining Table 12, it is seen that teachers' views were categorized into two themes: challenges encountered and solution suggestions. Under challenges encountered, the prominent codes are time constraints (n=6), lack of materials (n=6), student motivation (n=5), and classroom management difficulty (n=4). Under solution suggestions, the codes include use of low-cost alternatives (n=3), student roles and group support (n=2), and individual support and flexible planning (n=1). The codes indicate that teachers tried to find solutions to various structural and pedagogical issues encountered during implementations, particularly by focusing on strategies such as resource utilization, collaboration, and flexible approaches. Sample statements are provided below:
P11: "I often can't complete everything due to time constraints."
P3: "Classroom management is challenging due to large class sizes."
P1: "I made the projects more sustainable by using recycled materials."
P8: "I supported some processes with homework or group work."

Table 13. Teachers' Views on the Contributions of Design-Based Thinking STEM Applications to Personal Development

Theme	**Code**	**n**	**Participant**
Personal Development	Professional Development	1	P2
	Creativity Development	2	P4, P1
Classroom Contributions	Student Participation and Interaction	2	P1, P5

Upon examining Table 13, it is seen that teachers' views were categorized into two themes: personal development and classroom contributions. Under personal development, the codes include professional development (n=1) and creativity development (n=2), while under classroom contributions, the code of student participation and interaction (n=2) stands out. The codes indicate that teachers believe STEM applications enhance their individual professional competencies and strengthen their interactions with students in the classroom. Sample statements are provided below:
P2: "Using theses and articles supports my professional development."
P1: "Group work has a positive impact on classroom dynamics."

Table 14. Teachers' Views on Freedom and Constraints during Design-Based Thinking STEM Applications

Theme	**Code**	**n**	**Participant**
Freedom	Creativity and Flexibility	2	P1, P4
Constraints	Time and Curriculum	4	P4, P6, P7, P10

Upon examining Table 14, it is seen that teachers' views were categorized into two themes: freedom and constraints. Under freedom, the code of creativity and flexibility (n=2) appears, while under constraints, the code of time and curriculum (n=4) stands out. The codes indicate that some teachers felt free to engage in creative thinking and flexible implementation during STEM activities, while others expressed feeling constrained by time limitations and the existing curriculum structure. Sample statements are provided below:
P10: "The tight curriculum schedule restricts me."
P1: "I feel completely free to generate new ideas."

Table 15. Teachers' Views on Suggestions for the Development of Design-Based Thinking STEM Applications

Theme	Code	n	Participant
Development Suggestions	Teacher Training	2	P2, P3
	Resources and Infrastructure	2	P1, P3
	Student-Centered Practices	3	P1, P2, P3

Upon examining Table 15, it is seen that teachers' views were expressed under the "development suggestions" category with the codes of teacher training (n=2), resources and infrastructure (n=2), and student-centered practices (n=3). The codes indicate that teachers emphasized the need to strengthen student-centered approaches, increase teacher competencies, and improve physical facilities to enhance design-based thinking STEM applications. Sample statements are provided below:

P3: "I think there should be more teacher training."

P2: "Students should identify real-life problems themselves."

Discussion

The findings of this study reveal that STEM applications implemented through the design-based thinking (DBT) approach have a transformative influence on both students and teachers. The participating science teachers consistently emphasized that DBT-STEM practices foster deeper student engagement, creativity, and problem-solving, while also enhancing their own sense of professional fulfillment and pedagogical innovation.

According to the teachers, one of the most significant benefits of DBT-based STEM activities is the freedom it affords students to express their creativity. Activities rooted in real-life contexts allowed students to approach open-ended problems from multiple perspectives, leading to original and personally meaningful solutions. Teachers reported that the DBT stages—empathizing, defining, ideating, prototyping, and testing—enabled students to think beyond rote answers, internalize problems, and design user-centered, practical solutions. This design cycle also gave structure to creativity, guiding students in transforming abstract ideas into tangible products. Teachers described how classroom techniques like brainstorming sessions, open-ended questioning, and the use of creative drama reinforced these skills and encouraged a culture of exploration and risk-taking.

Teachers particularly noted the development of computational thinking skills as a standout gain from integrating STEM with DBT. Students were observed applying algorithmic reasoning, systematic problem-solving, and modeling approaches with increasing proficiency. Several teachers commented that this type of thinking emerged organically during design tasks, especially when students had to break complex problems into manageable steps or translate their ideas into structured, logical prototypes. These observations are consistent with the findings of Batı et al. (2017) and Sarı & Karaşahin (2020), who highlight the capacity of STEM education to enhance cognitive skill development and motivation.

Beyond student gains, the research underscores that DT-STEM practices prompted a shift in the professional identity and roles of the participating teachers. Many reported becoming more reflective and adaptive in their teaching practices. They felt more like facilitators and co-creators than traditional instructors, which contributed to a more democratic, student-centered classroom atmosphere. Teachers expressed that witnessing students' growth in such an active learning environment instilled a sense of excitement and rejuvenation in their own teaching careers.

Nevertheless, the transition was not without challenges. Teachers candidly discussed structural barriers such as time constraints, curriculum rigidity, lack of resources, and overcrowded classrooms. These obstacles often led to frustration and fatigue, threatening the sustainability of DT-STEM practices. As some teachers noted, the pressure to "cover content" sometimes clashed with the more exploratory, iterative nature of design thinking. These concerns reflect limitations identified in previous studies (Çakır & Altun Yalçın, 2020; Çınar & Terzi, 2021; İnançlı & Timur, 2018), where the institutional environment was shown to significantly influence the success of innovation in practice.

Despite these constraints, many teachers displayed resilience and agency by modifying lesson plans, using recycled or low-cost materials, and collaborating with peers to adapt the curriculum to better accommodate DBT-STEM practices. This aligns with Margot and Kettler's (2019) finding that success is more likely when the curriculum is flexible and aligned with engineering- and design-focused learning goals. Teachers in this study similarly stressed the need for systemic support, such as professional development, administrative encouragement, and infrastructure upgrades, to make DBT-STEM applications more sustainable.

In terms of classroom dynamics, the teachers observed not only cognitive growth but also social and emotional development among students. They highlighted students' improved communication, teamwork, and leadership skills, as well as greater willingness to participate and take initiative in group settings. As noted by one participant, "Students who rarely spoke before now lead group discussions during the prototyping phase." This observation echoes the findings of Çakır and Altun Yalçın (2020), who reported improvements in students' emotional engagement, willingness to participate, and ability to differentiate and articulate their ideas.

Conclusion

In conclusion, science teachers' reflections underscore the dual benefit of DBT-integrated STEM applications: fostering students' creative and computational thinking skills, while simultaneously promoting pedagogical renewal among teachers. However, the findings also highlight the need to address systemic challenges through targeted teacher training, improved school resources, and the curricular integration of DBT principles. For DBT-STEM practices to become a sustainable and scalable innovation, structural and institutional support must align with the pedagogical shifts teachers are already striving to implement.

Recommendations

Based on the findings obtained from this research, the following recommendations are made to ensure that STEM applications implemented through the design-based thinking approach become more effective, sustainable, and widespread:

• Strengthening teacher training programs is of great importance for design-based thinking and STEM applications to have an effective place in the education system. Therefore, in-service training programs aimed at enhancing teachers' methodological knowledge and application competencies should be expanded.

• Workshop areas suitable for STEM applications should be created in schools, essential material kits should be provided, and computer and internet infrastructure should be improved.

• Flexibility in terms of time and curriculum alignment should be ensured for the successful implementation of design-based and project-based applications. In this regard, a framework curriculum structure could be preferred for courses such as science practices.

Contributors

The authors declare that they have contributed equally to the conception, design, data analysis, and writing of this article.

References

Akgündüz, D., Aydeniz, M., Çakmakçı, G., Çavaş, B., Çorlu, M. S., Öner, T., & Özdemir, S. (2015). *STEM eğitimi Türkiye raporu*. Scala Basım.

Batı, K., Çalışkan, İ., & Yetişir, M. İ. (2017). Fen eğitiminde bilgi işlemsel düşünme ve bütünleştirilmiş alanlar yaklaşımı (STEAM). *Pamukkale Üniversitesi Eğitim Fakültesi Dergisi*, *41*(41), 91–103.

Büyüköztürk, Ş., Kılıç Çakmak, E., Akgün, Ö. E., Karadeniz, Ş., & Demirel, F. (2012). *Eğitimde bilimsel araştırma yöntemleri* (32. baskı). Pegem Akademi.

Creswell, J. W. (2013). *Nitel araştırma yöntemleri: Beş yaklaşıma göre nitel araştırma ve araştırma deseni* (M. Bütün & S. B. Demir, Edt.). Siyasal Kitabevi.

Çakır, Z., & Yalçın, S. A. (2020). Okul öncesi eğitiminde gerçekleştirilen STEM eğitimlerinin öğretmen ve veli görüşleri açısından değerlendirilmesi. *International Journal of Active Learning*, *5*(2), 142–178.

Çınar, S., & Terzi, S. Y. (2021). STEM eğitimi almış öğretmenlerin STEM öğretimi hakkındaki görüşleri. *Van Yüzüncü Yıl Üniversitesi Eğitim Fakültesi Dergisi*, *18*(2), 213–245. https://doi.org/10.33711/yyuefd.1028596

Elwood, K., & Jordan, M. E. (2022). Development of the Design Thinking and Instructional Lessons (DTAIL) model: A creative approach for teachers. *Educational Technology Research and Development*, *70*(5), 1781–1807.

Frear, L., & Fillip, C. (2019). Delving into design: Using design thinking in STEM curriculum environments. In *ICERI2019 Proceedings* (pp. 9226–9226). IATED.

Goldman, S., Carroll, M., Zielezinski, M. B., Loh, A., Ng, E. S., & Bachas-Daunert, S. (2014, June). Dive in! An integrated design thinking/STEM curriculum. In *2014 ASEE Annual Conference & Exposition* (pp. 24–440). ASEE.

He, W., Yan, J., Wang, C., Liao, L., & Hu, X. (2023). Exploring the impact of the design thinking model on fifth graders' creative self-efficacy, situational interest, and individual interest in STEM education. *Thinking Skills and Creativity*, *50*, 101424.

Ho, T. E. (2025). Outcomes of an integrated STEM with design thinking module on preschoolers' science process skills. *Journal of Early Childhood Research*, *1476718X251325675*. https://doi.org/10.1177/1476718X251325675

İnançlı, E., & Timur, B. (2018). Fen bilimleri öğretmen ve öğretmen adaylarının STEM eğitimi hakkındaki görüşleri. *Uluslararası Bilim ve Eğitim Dergisi*, *1*(1), 48–68.

Mahil, S. (2016). Fostering STEM+ education: Improve design thinking skills. In *2016 IEEE Global Engineering Education Conference* (pp. 125–129). IEEE. https://doi.org/10.1109/EDUCON.2016.7474564

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook*. Sage.

Öztürk, A. (2020). *Co-developing STEM activities through design thinking approach for fifth graders* (Unpublished doctoral dissertation). Middle East Technical University.

Partnership for 21st Century Skills. (2016). *P21 framework definitions*. https://www.marietta.edu/sites/default/files/documents/21st_century_skills_standards_book_2.pdf

Saavedra, A. R., & Opfer, V. D. (2012). Learning 21st-century skills requires 21st-century teaching. *Phi Delta Kappan*, *94*(2), 8–13. https://doi.org/10.1177/003172171209400203

Sarı, U., & Karaşahin, A. (2020). Fen eğitiminde bilgi işlemsel düşünme: Bir öğretim etkinliğinin değerlendirilmesi. *Turkish Journal of Primary Education*, *5*(2), 194–218.

Sarıkoç, Z., & Ersoy, H. (2022). Tasarım odaklı düşünme yaklaşımıyla STEM uygulamaları: SPAM eTwinning projesi örneği. *Fen Matematik Girişimcilik ve Teknoloji Eğitimi Dergisi*, *5*(2), 98–122.

Vianna, M., Vianna, Y., Adler, I. K., Lucena, B., & Russo, B. (2012). *Design thinking*. MJV Press.

Wingard, A., Kijima, R., Yang-Yoshihara, M., & Sun, K. (2022). A design thinking approach to developing girls' creative self-efficacy in STEM. *Thinking Skills and Creativity*, *46*, 101140.

Wu, B., Hu, Y., & Wang, M. (2019). Scaffolding design thinking in online STEM preservice teacher training. *British Journal of Educational Technology*, *50*(5), 2271–2287. https://doi.org/10.1111/bjet.12895

Yalçın, V., & Erden, Ş. (2021). The effect of STEM activities prepared according to the design thinking model on preschool children's creativity and problem-solving skills. *Thinking Skills and Creativity*, *41*, 100864.

Yıldırım, B. (2016). An analyses and meta-synthesis of research on STEM education. *Journal of Education and Practice*, *7*(34), 23–33.