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Examining BİLSEM Mathematics Teachers' Perspectives on Design Thinking Education[1]

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Abstract

This study aims to examine how BİLSEM mathematics teachers integrate Design Thinking (DT) approach into their educational processes and the effects of this approach on their professional development. The study was carried out with five mathematics teachers working in different BİLSEM institutions supported by the European Union IPA program and taking part in the "Gifted Education for Society 5.0" project. In the study, a qualitative research design was used. In addition to the semi-structured interview form as a data collection tool, researcher observations and research diary were also used to collect data. The data were analyzed using content analysis and the participants' views were categorized into themes. The findings revealed that teachers had limited knowledge about the DT approach before the training, but after the training, they made significant gains in personal development areas such as creative thinking, empathy, systematic thinking and professional development areas such as project-based learning, giving feedback, and working with groups. In addition, it was observed that they empathized more strongly with students and carried out individualized and enriched mathematics teaching activities. These findings suggest that DT provides innovative contributions to teaching processes by improving teachers' pedagogical competencies and can be used as an effective method in teacher education.

Keywords: Design thinking, special talent, mathematics, teacher education

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Introduction

Design thinking (DT) is an approach that is not limited to product development processes but can be effectively applied in many different fields where human-centered and creative problem solving is needed. Thanks to the systematic processes it offers for solving complex and uncertain problems, it is now used in a wide range of fields from the development of technology applications to economic initiatives, from health services to public policies, from business strategies to educational practices. In this context, its innovative applications and pedagogical contributions, especially in the field of education, make the integration of this approach into teaching processes increasingly important. DT is a problem-solving approach that can be applied in a wide variety of fields. This wide range of applications in different fields reveals the potential of DT to provide effective solutions to today's complex problems as an innovative and human-centered approach that encourages interdisciplinary interaction. DT is a human-centered problem solving approach that aims to produce innovative solutions by focusing on user needs. This methodology, which is effective in solving complex and uncertain problems, consists of empathy, problem definition, idea generation, prototyping and testing (Brown, 2009; Dorst, 2011). The process starts with the empathy phase, where users' problems are observed and their needs are analyzed from their perspective (Brown, 2009). This is followed by the problem definition phase, which involves asking the right questions and reframing the problem (Rittel & Webber, 1973). In the idea generation phase, creative thinking techniques are used to develop as many solutions as possible (Liedtka, 2015). In the prototyping phase that follows, the solutions are transformed into testable form in the form of low-cost and rapidly implementable models (Brown, 2009). The final phase, testing, involves evaluating the solution by users and improving it with feedback (Dym, 2005).

The Use and Benefits of Design Thinking in Education

Although the concept of design in education has a long history, the use of the DT approach in education is relatively new (Koh, Chai, Wong, & Hong, 2015). The phenomenon of design is shaped under the influence of technological developments and carries global responsibilities in this context (Felton, Zelenko & Vaughan, 2012; Nelson & Stolterman, 2003). With this approach, not only an instrumental technology adaptation in education, but also a transformation that is sensitive to human needs, empathy-based and centered on developing creative solutions has begun. Programs and syllabi carried out in the context of education are also a product of design. Therefore, schools are also built with functionality, rich stimuli, etc. in mind. Educational policies, on the other hand, encompass learning goals that provide support and justification for teachers. Public laws and school regulations are important for the proper functioning of the school system. In fact, schools, educational policies, educational programs, laws and each of their related areas are designed.

DT is considered as an effective method that transforms education at all levels from pre-school to higher education. In this context, research shows that DT is associated with different psychological and pedagogical contexts such as intelligence development, creativity (Rauth, 2010), engineering-based thinking (Dym, 2005), mood and motivation (Noweski, 2012). In particular, educational models developed in collaboration with the Stanford University School of Education and the Hasso-Plattner Design Institute (Stanford University d.school K12 Lab, n.d.). According to Kelley, students who participate in these programs are able to develop "new ideas, different perspectives, and personal solutions that make them feel good" (La O', 2009). Similarly, Goldman and Roth (history) argue that teaching students how designers solve problems enables them to make a difference both on an individual and global level and that this process offers significant advantages in today's competitive society.

DT has the potential to transform the pedagogical approaches of not only students but also teachers and administrators. Findings in the literature show that DT strengthens teachers' ability to empathize, think creatively, collaborate, and develop innovative teaching methods (Carroll, 2010; Henriksen, 2017). It is understood that DT not only increases student achievement but also creates a radical transformation in education by creating multidimensional effects on teacher competencies, administrative processes and learning environments. In this context, Scheer, Noweski, and Meinel's (2012) study in higher education revealed that DT principles are effective in developing complex problem

solving and teamwork skills. These findings also point to the need for teachers to develop interdisciplinary approaches and increase their capacity to cope with uncertainty. Hensley (2020) examined professional learning in PK-12 education through an innovative design thinking approach and stated that this approach helps educators adapt to changing standards and student needs. Yıldırım and Çetin (2021) reported that DT practices improved group work, prototyping, and creative thinking skills in STEM projects. Finally, in a case-based study conducted by Kocabaş (2022), it was observed that teachers who integrated DT processes into their classroom teaching practices were able to empathize more strongly with their students and develop more innovative teaching strategies. The common denominator of these studies is that DT is not limited to cognitive outcomes in educational practices; it supports a comprehensive development that includes affective and social dimensions. As a multifaceted approach that encourages 21st century skills such as empathizing, creative problem solving, collaborative development and innovative thinking, DT is seen to make meaningful contributions to teaching processes. This multi-layered transformation is especially important for mathematics education, where cognitive skills such as abstract thinking, problem solving and modeling are at the forefront. Considering that traditional teaching approaches limit student engagement and reduce learning motivation (Reschly & Christenson, 2012), it is imperative that teachers become not only knowledge transmitters but also creative practitioners who design learning experiences. Having design thinking skills can be an important advantage for mathematics teachers to construct empathy-based, innovative and student-centered learning environments by considering students' cognitive diversity and learning styles. In this context, design competence in mathematics education is not only a pedagogical preference but also a basic teacher competence required by the contemporary educational approach.

The Imperative of Design in Mathematics Education: Why Teachers Need to Be Designers?

In mathematics education, it is increasingly recognized that teachers' roles need to go beyond traditional approaches (Warr & Mishra, 2024). In this context, it is emphasized that mathematics teachers need to have a "design-oriented" way of thinking in order to gain the ability to produce instructional materials and shape lesson processes according to student needs (Burkhardt, 2006). Kieran, Doorman, and Ohtani (2015) stated that the teacher not only has a practitioner role in mathematics teaching, but also has the responsibility to develop instructional tools. Cobb, Confrey, and Lehrer (2003) stated that the teacher's decisions and interventions in the classroom have a direct impact on the learning processes of the students, and for this reason, they emphasized that teaching processes should be consciously "designed".

In today's mathematics education, it is seen that teachers should not only be knowledge transmitters, but also active designers of learning processes. In this context, the teacher should be considered not as a passive implementer of the curriculum but as a designer of learning environments. DT is an approach that provides a powerful framework for teachers to effectively take on the role of 'designer'. It provides a systematic process that enables teachers to identify classroom problems, generate solutions and test these solutions. DT helps teachers to better understand students' learning needs and shape their teaching accordingly.

DT provides teachers with the following skills:

Develop an empathetic approach that is sensitive to student needs,

Creative thinking about teaching materials and methods,

Improving teaching processes through trial and error,

Continuously reassess and reorganize the learning environment.

The Teaching and Learning Lab (TLL) at Harvard University defines DT as a mindset and approach to learning, collaboration and problem solving. It also provides a structured framework for identifying challenges, gathering information, generating potential solutions, developing ideas and testing solutions.

Scheer (2012) stated that design thinking provides a dynamic motivational support for teachers that supports critical thinking and can increase teachers' self-confidence. The same researchers emphasized the necessity of DT research in teacher education and stated that the missing link between theoretical

pedagogy and practice can be addressed with DT. Problem-based learning and DT tasks teach students the problem they want to solve and allow them to produce a solution using critical thinking and problem solving skills (Barton & Tan, 2018; Bush & Cook, 2019; Bybee, 2010; Von, Solms & Nel, 2017; Wirkala & Kuhn, 2011). In mathematics education, strategies that consciously apply the DT approach can positively affect students' approaches to solving difficult problems (Chin, 2019).

Purpose of the Study

This study aims to examine how mathematics teachers working in BİLSEM integrate the DT approach into their educational processes and the contributions of this approach to their professional development. In line with this purpose, the following questions were sought in the pre- and post-training interviews with the teachers:

1. Do you know what design thinking is? What are your shortcomings, if any? Explain.
2. What are the contributions of design thinking training in your field? Explain.

Method

Research Design: In this study, qualitative research method was preferred. Content analysis method, which is widely used in qualitative research, systematically examines and makes sense of the content in texts or documents. This method allows the researcher to categorize the data into specific categories, identify recurring patterns and reveal the main themes in the texts (Patton, 2015; Weber, 1990).

Participants: This study was supported by the TREESP 2.1. IQSES/309 project titled Society 5.0 for Gifted Education to improve the quality of special education services for gifted students. The project, which was financially supported by the Instrument for Pre-accession Assistance (IPA) of the European Union, was carried out by Bornova Şehit Fatih Satır Bilsem and Manisa (Turgutlu) Bilsem, Dokuz Eylül University and Celal Bayar University were involved as project partners. This study was conducted with 5 BİLSEM mathematics teachers who participated in the project.

Project Implementation Process: A comprehensive training program was implemented to overcome the deficiencies of BİLSEM teachers in terms of Community 5.0 and directing gifted students towards social problems. In this program, teachers received a DT-based multidisciplinary training. The main framework of the training was based on the United Nations' "climate action," "end poverty," "quality education," "responsible consumption and production" and 'sustainable cities and communities'. The training process started with comprehensive DT trainings that the trainers received from experts in Belgium, followed by online theoretical courses and face-to-face workshops and field practices in cooperation with METU Bilge İş. As a result of the project, teachers developed a training module to support the project-based work of gifted students and generate solutions to social problems. This module and project materials were made available to all teachers through an online learning repository, ensuring the project's nationwide impact. Ultimately, the project increased teachers' professional competencies, supported initiatives such as DENEYAP laboratories, and contributed significantly to the development of gifted students as individuals who produce technology, are sensitive to social problems, and are prone to collaboration.

Data Collection: A semi-structured interview form consisting of open-ended questions was used as a data collection tool. In the preparation of the interview forms, relevant studies in the literature, documents and expert opinions were utilized (Creswell, 2013; Patton, 2015). In the research, the implementation process was initiated by coming together with the teachers on the basis of volunteering to participate in the research. One of the most important data collection techniques in qualitative studies is undoubtedly researcher observations (Ekiz, 2013). The researcher kept a research diary starting from the pre-implementation phase of the study until the data were collected and analyzed.

Data Analysis: Content analysis method was preferred for analyzing the semi-structured interviews with the teachers, which is generally used in qualitative research. The data expressed by each participant in the interview form were transformed into descriptive concepts and relationships using content analysis (Yıldırım & Şimşek, 2011). The data obtained were summarized and interpreted descriptively according to the themes. Credibility, transferability, reliability and confirmability criteria were taken into consideration for the reliability of the research (Lincoln & Guba, 1985). Direct quotations were used in the study to accurately reflect the views of the teachers (Yıldırım & Şimşek, 2011).

Reliability: While creating the data collection tools, expert opinions were consulted and necessary corrections were made in line with the feedback received from these experts. Expert opinions played an important role in ensuring the accuracy of the content and structure of the tools. The accuracy of the data obtained using the semi-structured interview method was supported by participant confirmation and direct quotations. The opinions obtained from the participants were presented to the participants at certain intervals after the interview and the accuracy of these data was confirmed.

Findings

Table 1
Pre-training Teachers' Knowledge and Meaning of DT

Theme	Sub-theme	Sample Teacher Responses
DT Knowledge	Knowledge (yes)	"I know the steps of the design thinking process and I apply it in my activities." (T1)
	Knowledge (incomplete)	"I do not have in-depth knowledge in design thinking education and I do not know exactly how to use this approach." (T5)
Design Thinking Perception	Problem Solving and Analysis	"From the title of design thinking, I understand the process of producing solutions to problems with a systematic and analytical approach." (T2)
	User-Centered Approach	"From the title of design thinking, I understand the process of producing solutions by centering the needs of users." (T4)

The findings reveal that teachers have different cognitive levels regarding their knowledge of CLT. While one teacher (T1) stated that she knew the steps of the DT process and integrated it into her activities, the majority (T2, T3, T4, T5) stated that they lacked knowledge about this approach. This situation points to the need for professional development for DT. Teachers' statements regarding their perception of DT indicate that they focus on two of the main components of the approach: Problem solving and analysis (T2) and user-centered approach (T4). This shows that teachers tend to understand DT in terms of practical and functional aspects rather than abstract concepts. In general, it can be concluded that DT is comprehended by teachers in a limited but meaningful way and they need more support in terms of implementation. These findings suggest that teachers lack knowledge about the DT approach and need guidance in integrating this method into educational environments.

Table 2
Contributions of design thinking training to teachers

Theme	Sub-theme	Sample Teacher Responses

Personal Development	Adopting it as a philosophy of life	"I realized that this education is a philosophy of life that can be applied in real life." (T2)
	Discovery and development of creativity	"I realized that I can produce creative ideas by pushing my limits and turn them into opportunities." (T3)
	Systematizing thinking processes	"It contributed to controlling our thinking system and planning a systematic working process." (T4)
	Patience and empathy development	"The studies at the empathy building stage showed that we need to be patient and the importance of internalizing this practically." (T1)
	Awareness of applied learning	"An applied training process helped me better understand the reflection of theoretical knowledge in real life." (T5)
Professional Development	Professionalism in the project-based learning process	"I had the chance to experience the project-based processes in BILSEM in a more professional and systematic way." (T3)
	Encouraging creativity in students	"I learned how to help my students who have difficulty in finding original and creative ideas in this process." (T4)
	Structuring students' thoughts	"I gained competence in structuring students' thoughts and transforming them into projects. "(T5)
	Feedback giving and receiving processes	"Thanks to the feedback processes, I learned how to develop a better product with the students."(T1)
	Developing group work skills	"This training was very useful in teaching how to respectfully evaluate the ideas from the students and how to work with the group."(T5)
Contribution to Student Development	Recognizing the importance of empathy and the diagnostic phase	"I realized that the idea generation stage should be handled in more depth and detail after the empathy and diagnosis stage."(T2)
	Respect for students' individual thoughts	"I learned to organize my students' thoughts without directing them and to bring them to a conclusion."(T3)
	Leadership in product development and evaluation processes	"I observed that students became more mature when they tested the product they obtained and realized their shortcomings."(T2)
Contribution to the Teaching Process	Differentiated and enriched learning methods	"Design thinking offered an approach that supports individualized education processes with gifted students." (T1)
	Mathematics teaching and project applications	"I saw the importance of addressing the empathy, diagnosis and idea generation stages in detail with project students in mathematics teaching." (T3)

The multidimensional effects of DT training on teachers are revealed in the contexts of personal development, professional development, student development and teaching process. Teachers T2, T3 and T4 stated that they adopted DT not only as a pedagogical tool but also as a philosophy of life applicable in real life. In terms of creativity, T2, T3 and T5 stated that they were able to produce original ideas by pushing their limits and turn these ideas into opportunities. T1, T2, T3, T4 and T5 stated that they made significant contributions in personal development areas such as systematizing their thinking

processes, developing patience and empathy, and realizing the value of applied learning. In the context of professional development, T1, T2 and T3 were the teachers who stated that they developed a more professional approach in project-based learning processes, while T2, T3 and T4 stated that they learned how to guide students' creative thinking processes. T2, T4 and T5 emphasized that they improved their competencies in transforming students' thoughts into projects by structuring them. The teachers who stated that the processes of giving and receiving feedback contributed to their professional development were T1, T2, T3, T4 and T5; the teachers who stated that they improved their group work skills were T1, T4 and T5. In terms of student development, T2, T3, T4 and T5 were the teachers who stated that they realized the importance of empathy and identification stage; T2, T3 and T5 stated that they learned to respect students' individual thoughts, while T2 stated that he observed the maturation of students in product development and evaluation processes. In the context of contribution to the teaching process, T1, T2, T3, T4 and T5 were the teachers who stated that TST offered differentiated and enriched teaching methods; T1, T2 and T3 emphasized the importance of empathy, identification and idea generation stages especially in mathematics teaching.

Discussion, Conclusion, and Recommendations

The results of this study provide important implications for teachers' current knowledge and perceptions of Design Thinking (DFT) approach and its multifaceted effects on individual, professional, student development and teaching process. In general, the findings reveal that teachers have different levels of cognitive awareness about DT. While some teachers stated that they had mastered the basic steps of DT and integrated these steps into their lesson activities (T1), the majority (T2, T3, T4, T5) stated that they did not have enough knowledge about the approach. This situation clearly shows that there is a need for comprehensive professional development for teachers on CLT.

This finding is in line with the evaluations of researchers such as Carroll (2010) and Henriksen (2017) that DT is not yet widely used in educational systems and that teachers need support in implementing this approach. Teachers' interpretation of DT in terms of practical aspects such as "problem solving" and "user-centeredness" supports the studies of Razzouk and Shute (2012), who draw attention to the concrete application-based components of DT. In this framework, it can be said that teachers partially make sense of the DT approach, but they need more guidance to apply it effectively. In addition, the multi-layered effects of DT training on teachers were also emphasized in the study. Some of the teachers (T2, T3, T4) stated that they adopted DT not only as a pedagogical method but also as a way of thinking applicable in life. This deep level of acceptance is in line with Scheer, Noweski, and Meinel's (2012) findings that DT transforms individuals' thinking structures and problem solving approaches.

In the context of creativity, some teachers (T2, T3, T5) stated that they pushed their limits in developing original ideas during the DT practices and transformed these ideas into concrete opportunities. This is also consistent with the local findings of Korkmaz (2018) that DT improves creative thinking skills in his study with pre-service teachers. In addition, teachers stated that they made significant gains in terms of personal development in areas such as structuring their thinking processes, empathizing, developing patience, and realizing the value of applied learning (T1, T2, T3, T4, T5). Especially the emphasis on empathy skill shows that the user-centered structure of DT enables teachers to be more sensitive to student needs.

Within the scope of professional development, teachers (T1, T2, T3) stated that they developed a more systematic and professional perspective in project-based learning processes; they felt more competent in directing students' creative thinking processes, structuring their ideas and transforming them into projects (T2, T3, T4, T5). It was also emphasized that feedback processes contributed to their professional development and positively affected their teamwork skills (T1, T4, T5). These findings are in line with Warr and Mishra's (2024) study in which they emphasized the supportive role of DT in teachers' adaptation to the complex educational environments of the digital age.

In terms of student development, teachers stated that they realized the importance of empathy and diagnosis stages in the DT process and that they valued students' individual thoughts more (T2, T3, T4, T5). In addition, it was stated that students' mental and social development progressed observably in

the product development and evaluation processes (T2). In the context of contribution to the teaching process, it was stated that DT enabled the lessons to be presented in a richer and differentiated way (T1, T2, T3, T4, T5) and it was pointed out that empathizing, diagnosing and generating ideas especially in mathematics teaching increased instructional effectiveness (T1, T2, T3). These findings are in line with the findings of Voogt et al. (2015) and Henriksen (2017) on the transformative effects of DT on teaching practices.

The findings of this study show that despite teachers' initial lack of knowledge about DT, the training provided made significant and positive contributions to their personal and professional development, student development, and teaching processes. DT stands out as a powerful pedagogical tool that encourages teachers to move beyond their traditional roles and adopt more creative, collaborative and student-centered approaches. Future studies should investigate the long-term effects of DT and how these approaches can be integrated into educational systems on a broader scale.

In conclusion, the role of mathematics teachers as designers is not only a pedagogical choice but also a basic teacher competency required by modern education. It is concluded that design thinking in mathematics education will strengthen teachers' capacity to think creatively and develop innovative teaching strategies, and increase students' engagement and motivation. Therefore, it is important to include more DT in teacher education programs and to enable teachers to acquire these competencies. In line with these findings, educational policies and teacher education programs need to address design thinking more comprehensively. The following suggestions can facilitate the integration of SDT into mathematics teachers' education processes:

1. Teacher Education: It is important for teachers to develop their creative thinking and problem solving skills by incorporating more design thinking in teacher education (Scheer, 2012). This approach will help teachers to develop more effective and creative teaching strategies for students.

2. Applied Workshops: Practical design thinking workshops should be organized for pre-service teachers to improve their ability to solve real classroom problems. Such practices will allow teachers to reinforce both their theoretical and practical skills.

3. Mathematics Curriculum Integration: Design thinking should be integrated into mathematics curricula to support students' abstract thinking and problem solving skills (Yıldırım & Çetin, 2021). This integration will enable students to experience a more active and participatory learning process.

4. Professional Development: Continuous support of design thinking approaches in teachers' professional development processes will enable the adoption of innovative teaching methods (Kocabaş, 2022; Henriksen, 2017). In addition, professional development opportunities should be provided to help teachers cope with the challenges they face in this process.

Limitations

The sample of this study consists solely of mathematics teachers working in Science and Art Centers. This limits the generalizability of the research findings to teachers working in different types of schools.

Research and Publication Ethics

Research ethics approval was obtained from Dokuz Eylul University. The ethics committee granted approval based on the official letter numbered 287407.

Disclosure Statements

1.Contribution rates of the researchers: First Author 50%, Second Author 50%.
2.The authors report no potential conflicts of interest.

Credit Authorship Contribution Statement

Tuğçe Merve SAĞIR: Conceptualization, writing – review and editing, original draft writing, resources, visualization, qualitative analysis.

Burak KARABEY: Conceptualization, writing – review and editing, original draft writing, resources, visualization, qualitative analysis.

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