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Expanding The Limits of Mathematics: Interdisciplinary Education Experiences[1]

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Abstract

This study aims to examine the effects of interdisciplinary approaches in elementary school mathematics lessons and their implementation in the classroom. The study examines teachers' views on interdisciplinary approaches, the difficulties they face when implementing these approaches, and their effects on students' attitudes and motivation towards mathematics lessons. The study was conducted with a case study design, one of the qualitative research methods. The study group consisted of 10 classroom teachers working in Van province. A semi-structured interview form was used as data collection tools. In the interviews, teachers' implementation processes of interdisciplinary approaches, the difficulties they face and the effects of these approaches on student achievement were examined in depth. The data were analyzed using content analysis method. The findings of the study show that teachers generally associate interdisciplinary approaches with Turkish, Science, Social Studies and Life Sciences courses. In addition, the interdisciplinary approach was found to improve students' mathematical thinking skills and increase their motivation for mathematics. However, some teachers reported difficulties in implementing these approaches due to the intensity of the curriculum. In conclusion, interdisciplinary approaches have positive effects on student motivation and achievement. However, educational policies need to be strengthened to overcome the difficulties faced by teachers. In this direction, it is recommended that interdisciplinary trainings for teachers should be expanded and classroom materials should be diversified.

Keywords: *Interdisciplinary approaches, primary school mathematics teaching, mathematics lesson*.

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Introduction

Education systems aim for individuals not only to specialize in a particular discipline but also to make sense of knowledge by making connections between different disciplines. In this context, interdisciplinary approaches stand out as pedagogical methods that make students' learning processes more effective and meaningful (Chen, Cone, & Cone, 2007). Mathematics is one of the focal points of these approaches because it is inherently related to many fields such as science, engineering, arts, social sciences and even language learning. Integrating mathematics with other disciplines allows students to learn abstract concepts in concrete contexts and apply this knowledge in real life (Lesh & Doerr, 2003; Mousoulides et al., 2008).

The interdisciplinary teaching approach enables students to establish deeper relationships between disciplines from different perspectives. In this way, the connections between events, facts, concepts and ideas are learned more clearly and students can more easily construct new and different knowledge on these foundations (Mcdonald & Czerniak, 1994 as cited in Duman & Aybek, 2003). According to Jacobs (as cited in Brandt, 1991), with the integration of disciplines, even lessons that students dislike can become more enjoyable for them, as knowledge is associated with other fields. This is because with this approach, students better understand in which areas the lessons can be used in daily life. For example, students who realize that mathematics does not only consist of numbers, but is also used in areas such as science and social studies are excited by these relationships. Thus, interdisciplinary teaching is considered as an effective method that supports students' processes of making sense of knowledge by enabling a pragmatic use of disciplines (Aybek, 2001).

Interdisciplinary approaches contribute to the development of students' creative and critical thinking skills as well as linking mathematics with daily life. Mathematics is not only a theoretical field but also a tool used to solve practical problems. For example, linking mathematics to science provides students with an opportunity to understand how topics such as measurement, data analysis and statistics are applied in science experiments. This association is also supported by studies on STEM education (Bybee, 2013). On the other hand, integrating geometry and design concepts with art improves both students' aesthetic sensitivity and mathematical skills (Eisner, 2002). For example, pattern-making activities or studies on architectural structures are effective methods that can be used in this context. Scaling maps, analyzing historical events with mathematical models, or examining statistical data such as population growth are among the activities that can link mathematics with social sciences (Drake & Burns, 2004).

The mathematics curriculum in Turkey provides a framework that supports interdisciplinary learning (MoNE, 2018). In this framework, mathematics is encouraged to be associated with fields such as science, technology, engineering, and arts. However, research shows that this potential is not sufficiently reflected in classroom practices by teachers. For example, Güder (2013) stated that the main difficulties teachers face in designing interdisciplinary activities are lack of materials and lack of time. In another study, Karakuş et al. (2017) found that teachers lacked knowledge and adequate guidance in implementing interdisciplinary approaches. This indicates that interdisciplinary teaching strategies should be included more in teachers' professional development programs.

Studies on interdisciplinary approaches in the international literature show the positive effects of these methods on students' academic achievement, motivation and creative thinking skills. For example, a report prepared by OECD (2019) emphasized that interdisciplinary approaches are an effective method to develop students' 21st century skills. Similarly, Mousoulides et al. (2008) state that mathematical modeling activities increase students' ability to integrate knowledge from different disciplines. In the Turkish context, studies on this topic are limited (Ürey, Çepni, & Yıldız, 2013; Karakuş, Türkkan, & Karakuş, 2017; Kocabaş, 2022) and generally focus on STEM education. However, it is clear that more research is needed on the implementation of interdisciplinary approaches in elementary school mathematics lessons.

This study aims to examine the effects of interdisciplinary approaches in elementary school mathematics lessons and how these approaches are used in classroom practices. In particular, it aims

to contribute to the existing literature by addressing teachers' views on interdisciplinary approaches and the difficulties they face when implementing these approaches.

Method

Research Model

This research was conducted using the case study design, one of the qualitative research methods. A case study is a method that focuses on a particular phenomenon in depth to understand it in its context (Creswell, 2013). This study was designed to examine the use and effects of interdisciplinary approaches in elementary school mathematics teaching. The focus of the study is on the challenges and experiences of classroom teachers in implementing these approaches and their impact on student achievement.

Study Group

Purposive sampling method was used to determine the study group in the research. Purposive sampling allows in-depth study of situations that are thought to have rich information (Yıldırım & Şimşek, 2005). The study group consisted of 10 classroom teachers working in Van province. Participants were selected based on the following criteria: teachers had at least 5 years of professional experience, had experience or knowledge in organizing interdisciplinary activities, and worked in diverse geographical and socioeconomic contexts.

Data Collection Tools

The data were collected using a semi-structured interview form. In the interviews with the participating teachers, in-depth information was obtained about the processes of implementing interdisciplinary approaches, the difficulties encountered in these processes and the effects of these approaches on student performance. The interview form was developed in line with expert opinions and tested in a pilot study. Sample questions are as follows:

1. How do you relate mathematics to other subjects?
2. What are the effects of interdisciplinary approaches on students' mathematics achievement and motivation?”
3. What methods and techniques do you use to make connections with other disciplines in mathematics?
4. What difficulties do you face in carrying out interdisciplinary activities?

Data Analysis

The collected data were analyzed by content analysis method. Content analysis provides an in-depth data analysis by revealing themes and sub-themes (Cohen, Manion, & Morrison, 2007). The steps followed in this process are as follows: Interviews were transcribed. Codes were determined by reading the data repeatedly. The codes were grouped under themes explaining the use and effects of interdisciplinary approaches. The findings were interpreted in line with the aims of the study and examples of participants' views were presented.

Ethical Principles and Reliability

Considering the ethical dimension of the study, written consent was obtained from the teachers before participating in the study. Participants' identity information was kept confidential and the data were used only for research purposes. To ensure reliability: Interview forms were independently coded and compared by more than one researcher. Over 88% agreement was achieved between the coding (Miles & Huberman, 1994).

Findings

The findings of the study are presented on the basis of associating mathematics with other disciplines, the effects of interdisciplinary approaches on students, the methods and techniques used in the implementation of interdisciplinary approaches, and the difficulties encountered by teachers in the implementation process. In this context, the relationships of mathematics with Turkish, Life Science, Science, Social Studies, Visual Arts, Physical Education and Music courses were detailed. The findings are presented in tables and supported by teacher opinions.

Disciplines Associated with Mathematics

The table below summarizes how the mathematics course is related to other disciplines:

Table 1
Disciplines Associated with Mathematics

Theme	Sub-Theme	Codes	Frequency
Mathematics-Turkish Relation	Problem-solving context	Understanding problems accurately	7
	Writing skills	Writing stories with mathematical concepts	5
Mathematics-Life Sciences Relation	Daily life applications	Shopping problems	8
	Environmental awareness	Recycling calculations	6
Mathematics-Science Relation	Experiment results	Data analysis	9
	Natural phenomena	Mathematical models	7
Mathematics-Social Studies Relation	Map scales	Distance calculations	6
	Graph and table interpretation	Population growth analyses	5
Mathematics-Visual Arts Relation	Geometric patterns	Shape and symmetry studies	5
	Color theory and ratios	Color palettes	4
Mathematics-Physical Education Relation	Sports statistics	Success rate calculations	6
	Physical activities	Time and distance calculations	5
Mathematics-Music Relation	Rhythm and meter	Durations of musical notes	7
	Frequency and sound	Analysis of sound waves	4

According to Table 1, classroom teachers associate mathematics with life science, Turkish, social studies, science, visual arts, physical education and music courses. A more pronounced interdisciplinary approach was observed especially in subjects such as data analysis, shopping problems, writing stories with mathematical concepts, time and distance calculations, and rhythm exercises. Some of the opinions of classroom teachers on this issue are presented below.

> *"Writing stories about mathematics in Turkish lessons increases students' problem solving skills." (P1)*

> *"In science class, we use tables and graphs to analyze the results of experiments. This helps students understand the data better." (P8)*

> *"We make time and distance calculations in Physical Education class. Students learn to associate sports activities with mathematics." (P5)*

"During rhythm exercises in music lessons, students learn mathematics in a practical way by calculating note durations."(P3)

The Effects of Interdisciplinary Approaches on Students

Teachers' views on the effects of interdisciplinary activities on students were categorized as follows.

Table 2
Effects of Interdisciplinary Approaches on Students

Sub-Theme	Codes	Frequency
Mathematical Motivation	Increased interest in the lesson	9
	Desire for problem-solving	7
Understanding of Concepts	Relating to daily life	10
	Visualization skills	6
Creativity and Critical Thinking	Developing innovative solutions	4
	Ability to establish connections	5

The findings in Table 2 show that the interdisciplinary approach that teachers established between mathematics and other courses had positive effects on students in many aspects. In particular, classroom teachers stated that this approach contributed significantly to students' associating mathematics lessons with their daily lives, increasing their interest in the lesson, and making the lesson concrete through visualization. Some of the opinions of the classroom teachers on the subject are presented below.

"Creating geometric patterns in Visual Arts lessons helps students understand the concept of symmetry in mathematics." (P4)

"Rhythm exercises in music lessons offer a great opportunity to learn the concept of mathematical measurement." (P9)

"I observed that students' interest in the course increased in interdisciplinary activities. Especially activities related to daily life are very effective." (P7)

Methods and Techniques Used in the Application of Interdisciplinary Approaches

Teacher views on the methods and techniques used by classroom teachers when implementing interdisciplinary approaches were categorized as follows.

Table 3
Methods and Techniques Used When Implementing Interdisciplinary Approaches

Theme	Sub-Theme	Codes	Frequency
Teaching Methods	Collaborative Learning	Group work, project-based learning	5
	Problem-Solving Approach	Real-life problems, story-based activities	7
	Creative Drama	Role-playing, story reenactment	3
	Question-and-Answer	Interactive classroom discussions	2
Use of Materials	Visual Materials	Posters, charts, images	6
	Digital Tools	Smart boards, educational software	3
	Manipulative Materials	Geometric shapes, playing cards	4
Interdisciplinary	Interdisciplinary	Timelines, science experiments	5

Theme	Sub-Theme	Codes	Frequency
Planning	Activities		
	Daily Life Connections	Shopping scenarios, time and distance calculations	6

The findings in Table 3 show that classroom teachers use various methods and techniques when implementing interdisciplinary approaches. In particular, real-life problems and story-based activities stand out among the most preferred methods. In addition, shopping scenarios, time and distance calculations, posters, graphics and pictures are among the methods and techniques frequently used by teachers. Some of the opinions of classroom teachers on the subject are presented below.

> *"I frequently use group work and project-based learning methods in interdisciplinary studies. In this way, students learn to cooperate and establish connections between subjects more easily." (P5)*

> *"We create stories based on real life problems. For example, while we use math skills in shopping scenarios, we also make connections with social studies." (P7)*

> *"I try to associate science experiments with mathematics. This method is very effective especially in subjects such as measurement and data analysis." (P8)*

> *"Materials such as geometric shapes and playing cards help students to concretize the subjects." (P10)*

Challenges faced by teachers when implementing interdisciplinary approaches

The opinions of classroom teachers about the difficulties they face when implementing interdisciplinary approaches are categorized as follows.

Table 4
Challenges Faced by Teachers

Sub-Theme	Codes	Frequency
Time Management	Curriculum intensity	10
	Difficulty in activity planning	6
Lack of Resources	Insufficient materials	8
	Limited examples of applications	5
Inadequate Professional Development	Lack of methodological knowledge	7

The findings in Table 4 reveal that classroom teachers face some difficulties in implementing an interdisciplinary approach between mathematics and other subjects. Teachers stated that they experienced various problems especially due to the intensity of the curriculum, inadequacy of materials and lack of methodological knowledge. Some of the opinions of classroom teachers on this issue are presented below.

> *"We cannot allocate enough time for interdisciplinary activities in mathematics. The curriculum is very intense." (P2)*

> *"We want to integrate mathematics in lessons such as Physical Education, but we feel the lack of sufficient materials and guidance." (P6)*

> *"More professional training is needed to apply these approaches. Sample application videos or guidebooks would be very useful." (P10).*

Discussion, Conclusion, and Suggestions

This study examines how interdisciplinary approaches are applied in mathematics courses, teachers' experiences with these approaches and their effects on students. The findings show that the integration of mathematics with various subjects adds value to the learning process and enriches educational environments.

The findings revealed that mathematics can be effectively linked to disciplines such as Turkish, Life Science, Science, Social Studies, Visual Arts, Physical Education and Music. These connections deepened students' conceptual understanding, improved their ability to make connections to daily life, and increased their creative thinking capacities. For example, supporting the results of experiments with mathematical analysis in the Science course or practicing geometric patterns in the Visual Arts course strengthened the applicability of both interdisciplinary learning and mathematics. A story text prepared by associating it with the Turkish lesson enabled students to comprehend the subject better. Many similar interdisciplinary applications can provide significant benefits in teaching mathematics to students. Because it is possible to learn the knowledge and experiences of both social sciences and sciences within the framework of certain concepts with an interdisciplinary understanding (Yıldırım, 1996). In this way, students can bring together information from different disciplines and learn these subjects in a more meaningful way (Wronski, 1981).

Interdisciplinary approaches have positive effects on students, such as increased interest in the course, strengthened desire for problem solving and improved ability to relate to daily life. In particular, associating different fields such as music and physical education with mathematics prevented students from perceiving mathematics as an abstract course and contributed to their positive attitudes towards this course. As a matter of fact, the findings of the study are supported by the findings of Duman and Aybek (2003) that integrating different subjects increases motivation and achievement. During the study, it was observed that students exhibited high motivation and curiosity in the process of associating with other courses while learning the volumes of geometric objects. As a result, interdisciplinary approaches both increase students' achievement by making learning meaningful and strengthen their motivation towards the learning process.

Research findings show that different methods and techniques are used in the implementation of interdisciplinary approaches. In particular, it was observed that methods such as real life problems, story-based activities and daily life connections increased students' interest and motivation in the lesson. This result is consistent with Demirel et al. (2008)'s view that different methods positively affect achievement by supporting students' cognitive and affective development. It was observed that the methods and techniques used in the study provided students with the opportunity to think and produce by putting the student at the center, thus increasing the active participation of the students. This supports Işık's (2007) findings emphasizing the effect of the methods used in teaching.

Research findings show that classroom teachers face significant difficulties when implementing interdisciplinary approaches in mathematics lessons. The most prominent problems are the intensity of the curriculum, time management, lack of resources and inadequate professional development. Teachers stated that the intensity of the curriculum and the difficulty of activity planning prevent them from allocating sufficient time for interdisciplinary activities. This finding should be considered as an obstacle that limits teachers' efforts to deepen students' learning by establishing connections between mathematics and other lessons. It is also stated in the literature that the intensity of the curriculum prevents teachers from diversifying their teaching methods and creates a lack of flexibility in the teaching process (Demirel, 2008). Another important problem is the inadequacy of materials and the lack of application examples. Teachers stated that they experience a lack of sufficient materials and guidance to implement activities associated with mathematics, especially in some lessons. This makes it difficult for teachers to implement interdisciplinary activities effectively. This situation shows that educational materials should be diversified and guidance services for teachers should be strengthened. Finally, inadequate professional development stands out as another important obstacle that teachers face. Many teachers stated that they needed more professional training

to effectively implement interdisciplinary approaches. This suggests that teachers need continuous professional development opportunities to increase their knowledge and skills in such approaches. Other studies emphasize the importance of regular professional training and support for teachers to effectively use interdisciplinary teaching methods (Işık, 2007).

As a result, interdisciplinary approaches contribute to making mathematics education more meaningful and applicable. However, in order for these approaches to be implemented effectively, teachers need to be provided with more professional development opportunities and educational materials need to be enriched. The following recommendations are made based on the research findings.

• It is recommended that interdisciplinary approaches be integrated into the curriculum and that special time periods be allocated for these approaches.

• Training programs should be organized to guide teachers in interdisciplinary activities. These programs should be supported with sample applications and resource materials.

• The necessary materials for interdisciplinary activities should be developed and made available to teachers.

• More scientific research examining the effects of interdisciplinary approaches should be encouraged. These studies will provide data to better understand the experiences of teachers and students.

• Collaborative environments should be created between teachers from different disciplines and joint activity planning should be encouraged.

These suggestions can contribute to the more effective implementation of interdisciplinary approaches in mathematics classes.

References

Aybek, B. (2001). Disiplinlerarası öğretim yaklaşımı. *Eğitim Araştırmaları Dergisi, 3, 1-7.*

Brandt, R. (1991). On interdisciplinary curriculum: A conversation with Heidi Hayes Jacobs. *Educational Leadership, 49(1),* 1-8.

Brown, C. (2021). Interdisciplinary teaching in the classroom: A framework for integrating multiple disciplines. *Journal of Educational Practice, 15(3),* 75-89.

Bybee, R. W. (2013). *The case for STEM education: Challenges and opportunities*. NSTA Press.

Chen, W., Cone, T. P., & Cone, S. L. (2007). A collaborative approach to developing an interdisciplinary unit. *Journal of Teaching in Physical Education, 26, 103-124.* https://doi.org/10.1123/jtpe.26.2.103

Cohen, L., Manion, L., & Morrison, K. (2007). *Research methods in education (6th ed.). Routledge.*

Creswell, J. W. (2013). *Research design: Qualitative, quantitative, and mixed methods approaches (4th ed.).* Sage.

Demirel, Ö. (2010). *Öğretme sanatı.* Pegem Akademi Yayıncılık.

Demirel, Ö., Tuncel, İ., Demirhan, C., & Demir, K. (2008). Çoklu zekâ kuramı ile disiplinler arası yaklaşımı temel alan uygulamalara ilişkin öğretmen-öğrenci görüşleri. *Eğitim ve Bilim Dergisi, 33(147),* 14-25.

Drake, S. M., & Burns, R. C. (2004). *Meeting standards through integrated curriculum*. ASCD.

Duman, B., & Aybek, B. (2003). Süreç-temelli ve disiplinlerarası öğretim yaklaşımlarının karşılaştırılması. *Muğla Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, 11, 1-12.*

Eisner, E. W. (2002). *What can education learn from the arts about the practice of education?* John Dewey Lecture. Retrieved from http://www.infed.org/biblio/eisner_ arts_and_the_practice_of_education.htm (Accessed: 29/11/2024).

Işık, K. D. (2007). Çoklu zeka kuramı destekli kubaşık öğrenme yönteminin ilköğretim dördüncü sınıf öğrencilerinin matematik dersindeki akademik başarılarına ve kalıcılığa etkisi. *(Unpublished master's thesis). Çukurova University, Institute of Social Sciences, Adana.*

Karakuş, M., Türkkan, B. T., & Karakuş, F. (2017). Fen bilgisi ve ilköğretim matematik öğretmenlerinin disiplinlerarası yaklaşıma yönelik görüşlerinin belirlenmesi. *İlköğretim Online, 16(2),* 509-524. https://doi.org/10.17051/ilkonline.2017.304714

Kocabaş, A. (2022). Disiplinlerarası yaklaşımda bir model önerisi: Müzikle matematik öğretimi. *Disiplinlerarası Eğitim Araştırmaları Dergisi, 6(12), 125-137.*

Lesh, R. A., & Doerr, H. (2003). Foundations of model and modeling perspectives on mathematical teaching and learning. In R. A. Lesh & H. Doerr (Eds.), *Beyond constructivism: A models and modeling perspective on mathematics teaching, learning, and problem solving (pp. 1-19*). Lawrence Erlbaum.

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

Mousoulides, N. G., Christou, C., & Sriraman, B. (2008). A modeling perspective on the teaching and learning of mathematical problem solving. *Mathematical Thinking and Learning, 10(3),* 293-304. https://doi.org/10.1080/10986060802218132

McDonald, J., & Czerniak, C. (1994). Developing interdisciplinary units: Strategies and examples. *School Science and Mathematics, 94(1), 5-10.*

MEB. (2018). *Matematik dersi öğretim programı*. Ankara: MEB.

OECD. (2019). PISA 2018 results (Volume I): *What students know and can do*. OECD Publishing.

Ürey, M., Çepni, S., & Yıldız, C. (2013). Serbest etkinlik çalışmaları dersi kapsamında geliştirilen disiplinlerarası okul bahçesi programının öğrencilerin bazı matematik kazanımları üzerine etkisinin değerlendirilmesi. *Journal of Turkish Science Education, 10(3), 37-58.* https://doi.org/10.17051/io.2017.00068

Wronski, S. P. (1981). Social studies around the world. In H. D. Mehlinger (Ed.), *UNESCO handbook for the teaching of social studies.* Crolm Helm.

Yıldırım, A., & Şimşek, H. (2005). *Sosyal bilimlerde nitel araştırma yöntemleri (5th ed.).* Seçkin Yayıncılık.

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Ethical Declaration and Committee Approval

In this research, the principles of scientific research and publication ethics were followed.

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Proportion of the Author Contribution

All researchers contributed equally to this study