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Investigation of Middle School Students' Opinions and Self-Efficacy Beliefs on Mathematical Connection with Using Modelling Tasks*

Ortaokul Öğrencilerinin Modelleme Etkinlikleri Yoluyla Matematiksel İlişkilendirme Süreçlerine Yönelik Öz-Yeterlik İnançları ile Görüşlerinin İncelenmesi

Zülküf KILIÇ** **Kemal ÖZGEN*****

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ABSTRACT: The purpose of this study is to determine the opinions and self-efficacy beliefs of middle school students towards mathematical connections before and after the process in a learning environment prepared in the context of connections with different disciplines and including modeling tasks. An embedded experimental mixed method design was used in the research. The study was conducted with a sum of sixty-one students in the seventh-grade experimental and control groups for fifteen weeks, including the pre-test¬, post-test, and application process. As a data collection tool, mathematical modelling tasks, mathematical connection self-efficacy scale, and pre-post opinion forms for mathematical connection were applied. It was observed that there is no statistically meaningful difference between the pre-test and post-test scores of the groups in terms of mathematical connection self-efficacy. However, after the process, it was specified that connecting mathematics with other disciplines assisted the development of students' opinions on mathematics and different courses.

Keywords: Mathematical connection, mathematical modelling, middle school students, self-efficacy.

ÖZ: Bu çalışmanın amacı ortaokul öğrencilerinin diğer disiplinlerle ilişkilendirme bağlamında hazırlanan modelleme etkinlikleriyle tasarlanmış bir öğrenme ortamında matematiksel ilişkilendirmeye yönelik öz-yeterlik inançları ile görüşlerini ortaya çıkarmaktır. Araştırmada iç içe deneysel karma yöntem tasarımı kullanılmıştır. Araştırma yedinci sınıf deney ve kontrol grubundaki toplam 61 öğrenciyle ön test, son test ve uygulama süreci dahil olmak üzere on beş hafta boyunca yürütülmüştür. Veri toplama aracı olarak matematiksel modelleme etkinlikleri, matematiksel ilişkilendirme öz-yeterlik ölçeği ile matematiksel ilişkilendirmeye yönelik ön ve son görüş formları uygulanmıştır. Grupların matematiksel ilişkilendirme öz-yeterliği açısından ön test ve son test puanları arasında istatistiksel olarak anlamlı bir fark olmadığı görülmüştür. Ancak süreç sonrasında matematiğin diğer disiplinlerle ilişkilendirilmesinin öğrencilerin matematiğe ve farklı derslere ilişkin görüşlerinin gelişimine katkı sağladığı belirlenmiştir.

Anahtar kelimeler: Matematiksel ilişkilendirme, matematiksel modelleme, ortaokul öğrencileri, öz-yeterlik.

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***Corresponding Author*: Teacher, Yenişehir Bilim ve Sanat Merkezi, Diyarbakır, Türkiye, zulkuf_kilic@hotmail.com, https://orcid.org/0000-0003-4571-6910
***Prof. Dr., Dicle University, Diyarbakır, Türkiye, ozgenkemal@gmail.com, https://orcid.org/0000-0002-7015-6452

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In addition to the aims of the general education process, it is known that the main aim of mathematics education is to acquire mathematical thinking skills, and that mathematical thinking requires mathematical connections (Baki, 2018). Making connections plays a meaningful role in generalizing and abstracting some mathematical concepts (García-García & Dolores-Flores, 2021a), as well as being an important task for both teachers and students in classrooms (Mousley, 2004) where it is aimed to develop a mathematical understanding. The more mathematical connections a student makes in cognitive processes, the better his mathematical understanding can be considered (Chigeza, 2013; García-García & Dolores-Flores, 2021b). Since the connection is one situation that encourages the individual to think when encountered, procedures related to connection processes are needed in mathematical thinking processes (Narlı, 2016). Similarly, it is mentioned that mathematical connection helps students to remember and use many ideas and that mathematics learning can be strengthened with connection (Bossé, 2003).

It is aimed that students develop mathematical connection skills (Leikin & Levav-Waynberg, 2007; Özgen, 2013a, 2016), which are believed to be as important as communication, problem-solving, reasoning skills, and modelling, during the education process (Ministry of National Education [MoNE], 2013). Similarly, there is an emphasis on connection in curricula or process standards in our country and in different countries (Australian Curriculum, Assessment and Reporting Authority [ACARA], 2015; Curriculum Planning and Development Division [CPDD], 2012; MoNE, 2013, 2017; National Council of Teachers of Mathematics [NCTM], 2000; National Curriculum Board, 2009; Ontario Ministry of Education [OME], 2002). For example, in Spain, one of the European countries, it is encouraged to connect mathematics content with students' preparation for the future; in Ireland, problem-solving skills with concrete examples in mathematics, and in Estonia, middle school teachers are encouraged to connect geometry and symmetry with architecture and visual arts (Eurydice/EACEA/European Commission, 2012).

Mathematical connections can be defined as a process involving a wide range of mental activities such as making links between mathematical concepts and operations, learning fields (algebra, geometry, numbers, etc.) and different representations (verbal, algebraic, tables, figures, equations, graphs, concrete models, symbols, real life situations, etc.) with other disciplines and daily life (Kılıç, 2020). There are various classifications on mathematical connection in the literature. In his study, Eli (2009) handled connection under five different headings: procedural, characteristic/property, algebraic/geometric, derivational, and 2-D/3-D connection. In the study conducted by Leikin and Levav-Waynberg (2007), connections were categorized under three headings: (i) connections about the similarities and differences of the same concept, (ii) connections about different mathematical concepts and operations, and (iii) connections between different branches of mathematics. Rodríguez-Nieto et al. (2022), in their study, consider mathematical connections in terms instruction-oriented, different representations, procedural, implication or if–then, part-whole, meaning, feature, reversibility, and metaphorical types. Özgen (2013a) discusses mathematical connection under three headings: making connections with daily life, making connections with different disciplines, and making connections within mathematics itself.

In the literature, there are various studies examining participants' opinions, skills, and self-efficacy towards mathematical connections. Özgen (2013a) concluded in his study that students' knowledge, opinions, and experiences about connecting mathematics within itself, connecting it with different disciplines and connecting it with daily life should be improved. In the five-year project study that Shulman and Armitage (2005) conducted with teachers, the participants stated that when they made connections, they felt more empowered in terms of mathematics, and the teaching processes improved. Students can experience mathematics as a meaning-making task in which they form ideas, make connections, and engage in problem-solving tasks. When supported by appropriate environmental conditions, mathematics will become a meaning-making activity where students can develop metacognitive competencies and productive beliefs (Schoenfeld, 2022). As can be seen, the findings in the literature on mathematical connections reveal the contribution of mathematical connections to mathematics and its importance for mathematics learning and teaching. Because there is a close relationship between the learning and teaching process and self-efficacy (DiGregorio & Liston, 2018) and the importance of mathematical connections, it is thought that students' self-efficacy in mathematical connections should be investigated. In fact, Yavuz-Mumcu and Aktaş (2018) found a positive and significant relationship between mathematical connections skills and self-efficacy beliefs in their study.

In general, an individual's judgment of himself or herself regarding the capacity to organize the tasks necessary to perform a given performance and to successfully perform that task is called self-efficacy (Bandura, 1986). It is known that people who do not back down easily when faced with difficulties, who are persistent and patient, have high self-efficacy and make serious efforts to achieve a task (Schwarzer & Fuchs, 1995). For this reason, it has been emphasized in many studies that the self-efficacy perception is one of the notable features that should be emphasized in education (Aşkar & Umay, 2001; Hodges & Stackpole-Hodges, 2018).

It is thought that students' mathematical connection self-efficacy should be investigated because there is a close relationship between learning- teaching processes and self-efficacy (DiGregorio & Liston, 2018) and connection skills include the integrity of mathematics and its relationship with daily life and other disciplines. Mathematical connections should be taught to students throughout the mathematics education process and the development of students' self-efficacy in making connections, the importance of which has been emphasized by various studies, should be targeted. (García-García & Dolores-Flores, 2021a; Mousley, 2004). Therefore, it can be thought that students with high self-efficacy beliefs regarding making connections will also have changes in their beliefs about the connection of mathematics with daily life and other disciplines.

Mathematical modeling, which refers to the ability to solve real-world problems through mathematics (Kaiser, 2020), helps in connecting daily life with mathematics (Doruk & Umay, 2011) and serves as an effective tool for establishing relationships with other disciplines (Gürbüz et al., 2018). Mathematical modeling-based instructional processes interventions support the idea that disciplines such as science, engineering, and mathematics have a high potential to facilitate retention by improving students' self-efficacy (Czocher et al., 2019). Today, as mathematical thinking is needed to solve real problems, the products that need to be produced for a problem often require much more than short answers to routine math problems (Sriraman & Lesh, 2006). Therefore, the general idea accepted by today's mathematics educators is that individuals should be trained to produce solutions through mathematical modeling to problems that have the potential to be addressed mathematically in daily life, industry, and many other sectors. (Ural, 2018).

It is known that mathematical modelling is a powerful tool to help students who are faced with a world shaped by increasingly complex, dynamic, and powerful information systems, to better adapt to daily life and to develop high-level mathematical ideas and problem-solving processes (English, 2004). Sriraman and Lesh (2006) state that mathematical modelling education should start at an early age and emphasize that mathematical modelling encourages understanding and development of mathematical concepts in daily life, improves critical thinking and mathematical literacy. Similarly, English (2007) and Maaß (2005) state that integrating mathematical modelling into primary school curriculum should not be postponed to middle school and beyond. As a matter of fact, mathematical modelling, which is included in curricula and standards for mathematics teaching in different countries and whose necessity is emphasized (CPDD, 2012; NCTM, 2000), has also started to be incorporated in curricula at different education levels in our country (MoNE, 2017, 2018a). Mathematical modelling has started to be instructed as a compulsory course in Primary Education Mathematics Teaching and Middle Education Mathematics Teaching Undergraduate Programs, updated by the Council of Higher Education (CoHE, 2018). Similarly, in the Middle School Mathematics Applications Curriculum (MoNE, 2018b), it is clearly stated, along with the instructions, that mathematics application lessons will be taught according to the modelling approach.

There are approaches that consider mathematical modelling as skills that should be taught as a result of mathematics teaching (Blomhøj, 2007; Blum & Borromeo-Ferri, 2009; Lingefjärd, 2006; Maaß, 2006), as well as approaches that consider mathematical modelling as a tool for mathematics teaching (Lesh & Doerr, 2003). According to both perspectives, the activities prepared should include real life situations and interdisciplinary relationships (Blum & Borromeo-Ferri, 2009; English, 2006). These activities, which offer social interaction to students and make them experience a real problem-solving process, are called modelling activities (Lesh & Doerr, 2003). Model-Eliciting Tasks are defined as problem-solving tasks in which students constitute models and explain these models using mathematical thinking skills, test them and make necessary corrections to enable students to benefit from mathematical modelling in multifaceted real-life problems (Eric, 2008). Borromeo-Ferri (2018) states that there is a strong consensus that mathematical modelling can be defined as a task that involves switching back and forth between reality and mathematics, which is a fundamental feature of mathematical modelling.

Many studies emphasize the importance of mathematical modeling for interdisciplinary learning (Blomhøj, 2007; English, 2015; Kertil & Gürel, 2016; Sriraman & Dahl, 2009) and state that it is an ideal tool for interdisciplinary learning (English, 2007). However, when the studies on mathematical modeling are examined, it is seen that while there are many studies dealing with mathematical modeling in the context of connecting with daily life (Blum & Leiss, 2005; Borromeo-Ferri, 2006, 2010; Cai et al., 2014; Lesh et al., 2003), there is a limited number of studies dealing with mathematical modeling in the context of connecting with different disciplines (Domínguez et al., 2015; English, 2007; Güder & Gürbüz, 2018).

Krawitz and Schukajlow (2018) state that in addition to mathematical content, mathematical modeling and other problem types do not have a significant effect on students' self-efficacy beliefs. However, considering that mathematical modeling is an effective tool in the context of connecting with different disciplines (English, 2007), it can be considered that self-efficacy beliefs and opinions towards mathematical connection processes through mathematical modeling can be examined. Based on these thoughts, the aim of this study is to determine the opinions and self-efficacy beliefs of middle school students towards mathematical connections before and after the process in a learning environment prepared in the context of connections with different disciplines and including modeling tasks. Therefore, in this research, the main research problem can be stated as "How are students' mathematical connection self-efficacy beliefs and opinions before and after the learning process designed with modelling tasks?" In addition, the research focuses on the following sub-problems.

- Is there a meaningful difference between the mathematical connection self-efficacy beliefs of the students in control and experimental groups after the application process designed with modelling tasks?
- What are the experimental group students' opinions on mathematical connection before and after the application process designed with modelling tasks?
- What are the experimental group students' opinions on the importance of connecting mathematics with other disciplines before and after the application process designed with modelling tasks?

Method

Research Design

This study is mixed research conducted to investigate middle school students' mathematical connection self-efficacy beliefs and opinions in a learning environment designed with modelling tasks prepared in the context of connecting with other disciplines. The research used an embedded experimental mixed method design (Creswell & Plano Clark, 2018, p. 98), in which a qualitative phase can be added to a quantitative study. In line with the aim of the study, qualitative data were used to support the dominant quantitative data, and this design was preferred to seek answers to the secondary problems in the study. In the quantitative part of the study, a quasi-experimental design with pre and post-test control group was implemented. While the experimental group was subjected to a special intervention during the course designed in the research, no experimental intervention was made to the control group. However, in this study, quantitative data were emphasized in accordance with the mixed design of the research. Quantitative and qualitative data were collected simultaneously in the research; qualitative data were blended with quantitative data and quantitative data were supported.

Participants

This study was conducted with seventh grade students training in a public school located in the center of one of the metropolitan cities of Türkiye. Before the research, it was thought to work with eighth graders, but since the central exam anxiety of the eighth graders was high, it was decided to work with the seventh graders.

The study group was selected with easily accessible case sampling, one of the purposive sampling methods. Since it is not possible to randomly distribute the students to the control and experimental groups for the experimental process, the group matching design (Büyüköztürk et al., 2019) was used by the researcher on the existing groups. Among the groups in the school where the researcher worked, the two classes with the closest mathematics course grade point average were assigned as the control and experimental groups. Mathematics grades of the students in the control and experimental groups were obtained from the e-School system. It was observed that the number of students with a grade point average of 70 points and above was equal and fourteen in the experimental and control groups. Similarly, while the percentage of students with a grade point average of 55 and above was 62.9% in the control group, it was 55.9% in the experimental group. According to these values, it can be said that the control and experimental group students are similar with respect to mathematics achievement.

In addition to the sampling methods given, the embedded sample relation, one of the sampling designs used in mixed research, was used. In the embedded sample relationship, the participants chosen for one stage of the study constitute a particular part of the participants chosen for the study's other phase (Johnson & Christensen, 2014). According to the embedded sample relationship, the control and experimental groups consisting of a sum of sixty-one students were selected in the quantitative part of the study, while only the experimental group students consisting of thirty-four students were selected in the qualitative part of the study. Since the real names of the students were not wanted to be given in the study, the experimental group students were coded as "E1, E2, E3, E4 ..." and the control group students were coded as "C1, C2, C3, C4 ...".

Data Collection Tools

Mathematical Connection Self-Efficacy Scale

The Mathematical Connection Self-Efficacy Scale improved by Özgen and Bindak (2018) was used to specify students' self-efficacy perceptions towards mathematical connection. This scale was also used in different studies with middle school students (Kaya, 2020; Yılmaz, 2022). Although this mathematical connection self-efficacy scale is a five-point Likert-type scale, it consists of six negative, sixteen positive, twenty-two items, and five factors. In this context, the factors were named as (i) difficulty, (ii) using mathematics, (iii) connecting mathematics within itself, (iv) connecting with other disciplines, and (v) connecting with daily life. A reliability and validity analysis of the scale was performed, and it was determined that the scale was usable. The Cronbach alpha reliability coefficient of the scale is 0.85. In this study, the Mathematical Connection Self-Efficacy Scale was applied to the students in control and experimental groups twice, after and before the application process. The Cronbach's alpha reliability coefficient was determined as 0.76 and 0.83 before and after the application process respectively in this study.

Pre- and Post-Opinion Forms

Opinion forms containing structured questions were prepared to specify the opinions of the students on mathematical modelling, mathematical connection, and the relation of mathematics in other disciplines throughout the study process. "Pre-Opinion Form" for the pre-implementation and "Final Opinion Form" for the post-implementation were prepared. In these forms, there are three questions in the pre-opinion form and three in the final opinion form for the students to make explanations. The questions that appear in the opinion forms are listed below.

Questions for the pre-opinion form:

- Did your mathematics teachers relate to the topics or concepts you have learned in your other lessons? Explain with concrete examples.
- Did your teachers make connections between the subjects or concepts related to mathematics in your courses such as social studies, science, physical education, and visual arts? Please explain with concrete examples.
- In your opinion, what kind of benefits will it be for you to connect mathematics with your different courses? Please explain with justifications and give concrete examples.

Questions for the final opinion form:

- Has making a connection between your mathematics course and your courses such as social studies, science, physical education, and visual arts contributed to your interest in mathematics and your success in mathematics? If so, how did it contribute? Please explain.
- Did connecting the concepts related to your courses such as science, social studies, visual arts, and physical education with some basic concepts in your mathematics course contribute to your interest and success in these courses? If so, how did it contribute? Give reasons for your opinion. Give specific examples.
- What kind of difficulties or challenges do you think mathematics may have in its connection with other courses? Explain with justifications. Give concrete examples.

The aim of the questions in the pre-opinion form was to determine the students' level of knowledge about mathematical connections and, connection knowledge, to get their opinions about the benefits of this type of connections and to enable them to give examples. The final opinion form, which was used after the experimental process, assumed that the students had knowledge about mathematical connections and asked them to give their opinions and examples about the contributions of connecting mathematics with other disciplines, both to mathematics and to other disciplines, and the difficulties that might be encountered in this process. Expert advice was sought on the suitability of the questions on the opinion form for eliciting students' opinions, and the necessary arrangements were made. Then, to specify whether the questions were understandable or not, the opinions of the students who will not participate in the research were taken, necessary arrangements were made, and the forms were made ready to use in the research.

Mathematical Modelling Tasks

In this study, when developing mathematical modelling tasks, attention was paid to following the curriculum and acquisitions of mathematics and other disciplines, making interdisciplinary connections, developing modelling skills and creating different mathematical models for given problem situations. The tasks were designed considering the readiness level of the students and identifying outcomes appropriate to their level, including topics and concepts from previous semesters. In addition, topics were selected that were appropriate to the students' interests and that covered different disciplines, and connects were made to real-life contexts and interdisciplinary topics. Factors such as the applicability of the tasks in the classroom environment, the simplicity of the language and the suitability of the visuals were also considered. As in Kerpiç and Bozkurt's (2011) study, design, and implementation principles such as the roles of students and teachers, materials to be used, classroom organization, time management and evaluation were also considered.

In addition, while preparing the modelling tasks, the characteristics of the mathematical modelling tasks created by Tekin Dede and Bukova Güzel (2014, p. 98) within the framework of the literature and the principles of the modelling tasks stated by Lesh et al. (2003, p. 43) were examined. On the other hand, considering the basic components of modelling tasks (Chamberlin & Moon, 2005), the tasks were divided into stages such as "reading passage", "readiness questions", "problem situation", and "presentation of solutions". "Reading passage" is a reading page, like a newspaper article, whose purpose is to familiarize and prepare you for the context of the problem situation. "Readiness questions" are preparatory questions, that a student answers about a previous article. Their purpose is to familiarize and prepare for the context of the problem situation. The "problem situation" can be of various kinds, such as a diagram, a table, a map. It is the basic component of the modeling task. In the "presentation of solutions" section, a mathematically complex problem is solved, and the model is generalized to subsequent situations.

In addition, care was taken to connect modeling tasks to learning outcomes in mathematics and other disciplines (science, social studies, visual arts, physical education, sport, information technology). The tasks were designed to include mathematical concepts such as ratio-proportion, length measurement, equation, volume measurement, percentage, circle graph and whole numbers. Connections were made to the themes of natural resources, national economy, history, stripes and scale on maps in the social studies course, force, mixtures and speed in the science course, perspective in the visual arts course, healthy living in the physical education course, and data storage in the information technology course.

While designing the tasks, arrangements were made in keeping with the aim of the study, such as what to do during the two lesson hours, the role of the student and the teacher, the materials to be used, the classroom organization, the use of time, measurement, and evaluation. The Task Evaluation Form, which includes titles such as the appropriateness of the outcomes, language expression, tables/graphics and visuals, connection with different disciplines, mathematical modeling, and appropriateness to the outcomes of different disciplines, was prepared and evaluations were taken from five academicians and three graduate students who are experts in their fields and necessary arrangements were made. After the necessary arrangements were made in the tasks, a pilot study was conducted with 8 students outside of class time. The task development process was completed by considering the feedback from the students.

Data Analysis

The quantitative data in this study are based solely on the data obtained with the mathematical connection self-efficacy scale. The obtained quantitative data were analyzed using the SPSS 22 program.

Since the group size was less than 50, the Shapiro-Wilk test was used to examine whether the data obtained showed a normal distribution. The Shapiro-Wilk coefficients of the post-test control and experimental groups were found to be less than 0.05, and the ratio of the skewness coefficient (S.C.) to the standard error (S.E.) was specified to be less than 1.96 by looking at the z statistics. The fact that the S.C.S.E. ratio is less than 1.96 can be interpreted as the distribution does not deviate excessively from the normal (Büyüköztürk, 2014). For this reason, t-test, one of the parametric tests, was used in the analysis of the data. First, descriptive statistics were used to determine whether there was a significant difference between the post-test self-efficacy scores of the control and experimental group students. The t-test was used for independent measurements to specify whether the difference was meaningful. For each control and experimental group, the t-test was used depending on measurements.

The qualitative data of the research were obtained by using the pre and post opinion forms from the data collection tools. Firstly, the opinions of academics who are experts in their field were sought before deciding whether the questions in the opinion form were suitable for eliciting students' opinions. A pilot study was then carried out with students who were not involved in the research to see if the questions were understandable, and their opinions were considered. The forms were finalized after necessary arrangements were made based on expert opinions and pilot study data.

Thematic analysis and content analysis methods, which are among the qualitative analysis methods, were used in the student opinions in the pre- and post-opinion forms. The student opinions analyzed by content analysis method were systematically organized, codes and categories were created, explanatory concepts and relationships were determined, and the data were interpreted accordingly. Thematic analysis was used in cases where the student responses in the opinion forms could not be conceptualized in accordance with the content analysis. Because thematic analysis is more superficial than content analysis, and direct quotations are included to reflect the opinions of individuals in a striking way (Çepni, 2012).

Implementation Process

Three weeks before the application process, the groups were applied a pre-opinion form, a mathematical connection self-efficacy scale, and three mathematical modelling problems as a pre-test. After the application process, which lasted for nine weeks and included modelling tasks with the experimental group, post-tests were implemented for the groups for three weeks. As a post-test, the final opinion form, mathematical connection self-efficacy scale, and three mathematical modelling problems were applied, and the process was completed.

In this study, quantitative data was collected from both groups, while qualitative data was only collected from the experimental group. This preference was based on the aim to subject the experimental group to the intervention and to analyze in depth the effects of this process on the participants. As the control group did not receive the experimental intervention, it was predicted that collecting qualitative data from this group would not make a meaningful contribution to the research. Quantitative data was considered sufficient to compare the two groups. During this process, qualitative and quantitative data were picked up, and analyses were made in conformity with the research problems. Thus, meaningful findings on the subject were tried to be obtained.

This study lasted fifteen weeks in total and included three weeks of pre-test, nine weeks of implementation and three weeks of post-test phases. The pre-test and post-test modelling tasks consisted of the same modelling tasks. The first task connected the concepts of equality and equation in mathematics with the concepts of weight and mass in science; the second task connected the concepts of length measurement and ratio in mathematics with speed in science. The third task connected volume measurement in mathematics with natural resources in social studies. In the pre-test and post-test applications, students were asked to complete the modelling tasks individually in 40 minutes. The pre-opinion and post- opinion forms and the pre-test and post-test mathematical connection self-efficacy scale were applied individually to the students before and after the experimental process.

Throughout the experimental process, different mathematical modelling tasks were carried out each week, prepared in advance by the researcher and implemented over nine weeks. Each modelling task used in the experimental process was conducted in the preparation, implementation, and evaluation stages in accordance with the constructivist approach. The experimental group was heterogeneously divided into groups of three. Before each task, the students were prepared with homework, presentation and research tasks given in the previous weeks. In the preparation phase, the students gave presentations on the homework they had prepared in class and then the teacher showed appropriate videos, presentations or computer applications related to the task and asked preparatory questions about the problem situation. The roles of teacher and students were clearly defined before each task. This reduced the role of the teacher and created a collaborative learning environment in which students were more active. As part of the constructivist approach, the teacher minimized the role of narration and explanation and encouraged students to solve problems in a rich discussion environment. After the application, one or two groups were expected to present solutions to the class.

Finally, after each task, different perspectives were developed by discussing the students' proposed solutions and providing a constructive evaluation environment. This process helped students to better understand the connections between mathematics and other disciplines. An example of a task and a sample daily schedule suitable for the experimental process is given in Appendix 1.

Ethical Procedures

During the research, permission was obtained from the Dicle University Educational Sciences Ethics Committee with the decision number 90871155-044 dated 03/01/2018 and Directorate of National Education. While conducting this research, attention was paid to the "Higher Education Institutions Scientific Research and Publication Ethics Directive".

Findings

This section is discussed under two headings and focuses on the sub-problems of the research. Quantitative data are presented under the first heading and qualitative data are presented in the second heading.

Findings from the Analysis of the Student Mathematical Connection Self-Efficacy Scale

In Table 1 below, independent samples t-test results are given to reveal whether there is a meaningful difference between the self-efficacy scores for the mathematical connection skill of the students in the control and experimental groups.

Table 1

T-Test Results of Control and Experimental Group Students' Pre-test Self-Efficacy Scores for Mathematical Connection

Group	*N*	*M*	*S*	*Sd*	*t*	*p*
Experimental	34	54.26	13.68	59	-.609	.54
Control	27	56.55	15.65			

According to the t-test results of the pre-test self-efficacy scores for mathematical connection in Table 1, no significant difference could be found between the groups [$t(59)=-.609$, $p>.01$]. Although the mean self-efficacy scores for the mathematical connection of the control group students ($M=56.55$) were more significant than the experimental group students ($M=54.26$), the t-test results show that this difference is not meaningful. According to these values, it can be interpreted that there is no relationship between groups and self-efficacy scores for mathematical connection.

The results of the independent samples t-test conducted to examine whether the difference between the post-test mathematical connection self-efficacy mean scores of the experimental and control groups was statistically significant are presented in Table 2.

Table 2

T-Test Results of Control and Experimental Group Students' Post-test Self-Efficacy Scores for Mathematical Connection

Group	*N*	*M*	*S*	*Sd*	*t*	*p*
Experimental	34	55.55	9.49	59	-1.804	.07
Control	27	60.29	11.00			

According to the t-test results of the post-test self-efficacy scores for mathematical connection, there is no meaningful difference between the groups, [$t(59)=-1.804$, $p>.01$]. Although the mean self-efficacy scores for mathematical connection of the control group students ($M=60.29$) were higher than the experimental group students ($M=55.55$), the t-test results show that this difference is not meaningful.

According to these values, it can be interpreted that there is no relationship between the groups and the post-test self-efficacy scores for mathematical connection.

Table 3 shows the results of the t-test performed to specify whether there is a meaningful difference between the post-test and pre-test self-efficacy scores for the mathematical connection of the control group students.

Table 3

T-Test Results of Control Group Students' Pre-test and Post-test Self-Efficacy Scores for Mathematical Connection

Test	*N*	*M*	*S*	*sd*	*t*	*p*
Pre	27	56.55	15.65	26	-1.149	.26
Post	27	60.29	11.00			

According to the t-test results in Table 3, there was no meaningful difference between the pre-test and post-test self-efficacy scores for the mathematical connection of the control group students [$t(26)=-1.149$, $p>.01$]. There was an increase in the post-application mean score ($M=60.29$) compared to the pre-application mathematical connection self-efficacy mean score ($M=56.55$) of the students. However, this increase displays that the application process does not have a meaningful impact on the student's self-efficacy scores averages for mathematical connection. In Table 4, the t-test results are given to specify whether there is a meaningful difference between the post-test and pre-test self-efficacy scores for mathematical connection of the experimental group students.

Table 4

T-Test Results of Experimental Group Students' Post-test and Pre-test Self-Efficacy Scores for Mathematical Connection

Test	*N*	*M*	*S*	*sd*	*t*	*p*
Pre	34	54.26	13.68	33	-.548	.58
Post	34	55.55	9.49			

In Table 4, no significant difference could be detected between the post-test and pre-test self-efficacy scores for mathematical connection of the experimental group students [$t(33)=-.548$, $p>.01$]. There is an increase in the post-application mean score ($M=55.55$) compared to the pre-application self-efficacy mean score for mathematical connection of the students ($M=54.26$). This increase shows that there is no meaningful difference between the pre-test and post-test self-efficacy sum scores for mathematical connection of the experimental group students. To determine whether the t-test results and the experimental group students' opinions on mathematical connection show parallelism, opinions of the students in the pre-opinion and post-opinion forms were examined.

Findings From the Student Opinion Forms

The opinion forms were aimed at revealing if there was a difference in the experimental group students' opinions towards mathematical connection. In these forms, structured open-ended survey questions were used, and the answers given by the students were analyzed by using content analysis and thematic analysis methods with a qualitative approach.

In the pre-test opinion form, the open-ended question "Did your mathematics teachers relate to the topics or concepts you have learned in your other lessons? Explain with concrete examples" was analyzed thematically with a qualitative approach. In this question, which was answered by all students, twenty-five of the students stated that mathematics was connected with science lesson, four to social studies lesson, one to physical education lesson, one to music lesson, and one to visual arts lesson. Although two students stated that a connection was made, they did not give information about which course the connection was made with. Although many of the students mentioned that there was a connection between mathematics and a different discipline, they did not give any concrete examples. The number of students who gave concrete examples about the connection was limited. For example, the student E23 drew attention to the connection made with the science lesson with the statement, "Yes, my mathematics teacher had an example showing weight on an equal-armed scale on the subject of equations, and he related it to the weight subject in the science lesson". The E18 student, on the other hand, talked about the connection made with the social studies lesson with the statement, "Sometimes he touches on these subjects for our lesson, for example, he explained it with the title of maps, measurement and scales". Similarly, the student E17 mentioned the connection between physical education lessons and number patterns in mathematics lessons with the statement, "I think there is math, for example, and the body says two steps back in the body, it is related to mathematics". Analysis of students' responses revealed that although the majority of students stated that connections are made with other disciplines in mathematics class, the number of explanations supported by concrete examples was limited. This situation shows that students have the impression that connections are made, but they are unable to understand these connections in depth. In other words, students show a superficial awareness but lack in-depth knowledge or concretization. In this context, the need for teachers to make stronger and more explicit connections with other disciplines in mathematics education comes to the fore.

Similarly, the answers of students to the open-ended question, "Did your teachers make connections between to the subjects or concepts related to mathematics in your courses such as social studies, science, physical education, and visual arts? Please explain with concrete examples." in the pre-opinion form were subjected to thematic analysis, and the findings gained were submitted in Table 5 by creating codes and categories. As a result of the thematic analysis of the students' responses, the general concepts mentioned by the students in other disciplines were rephrased by the researcher by connecting them with the related mathematical subjects and concepts. The table shows the codes created by the researcher in this process.

Table 5

Students' Opinions in the Pre-Opinion Form on the Connecting of Other Courses' Topics or Concepts with Mathematics

Category	1st Degree Subcategories	2nd Degree Subcategories	Codes	*f*
Connection Subjects or Concepts of Other disciplines with Mathematics	Science	Velocity, equal-arm scale, volume, solid pressure	Ratio -proportionality, equations, volume measurement units	22
	Social sciences	Parallel and meridian data strip	Coordinate system, integers	2
	Physical education	Walking pattern	Measuring length, number patterns	2
	Music	Beats	Fractions	1

While twenty-seven of the students stated that they made connections with subjects or concepts related to mathematics in other disciplines, two of them did not answer the question at all, and five of them did not answer this question. Of the students who stated that connections were made with the mathematics lesson while the concepts of other disciplines were being taught, twenty-two of them indicated that they made connections with the subjects and concepts related to the science lesson, two of them in the social studies lesson, two of them in the physical education lesson, and one in the music lesson. Drawing attention to the connections related to the subjects and concepts related to the science lesson, the student E6 stated that the subject of velocity was connected with mathematics with the statement, "Science teacher made connections about the speed with subjects related to mathematics". The student E1, on the other hand, stated that the connection was made about equal-armed scales with the statement, "The math teacher and the science teacher made a connection between weight and force". However, although these students stated the subjects and concepts related to the science lesson, they did not use any statements about which subject and concept related to the mathematics lesson were connected. Similarly, the student E9, among the students who indicated that the social studies lesson was connected with the mathematics lesson, mentioned the subject related to mathematics in the statement "The parallels and meridians we studied in the social lesson were the same as coordinates in the mathematics lesson", but did not state that the teacher did this. In the same vein, the student E30, who referred to the connection made in the music lesson, did not mention the subject and concept connected to mathematics, although he stated that he made a connection with mathematics with his explanation "The music teacher made a connection with mathematics while he was explaining the beats". In general, when the students' opinions were examined before the application, many of the students specified that they made connections with mathematics in different courses. However, the students did not give any information about which subjects and concepts in mathematics were connected with at the time of the connection. As can be seen from the sample of students' expressions, although the students stated that they made connections between different disciplines and mathematics, these connections were generally superficial and specific mathematical concepts were not clearly expressed in the expressions used by the students. This shows that students' awareness is mostly based on general knowledge and that they have difficulty in making deep connections with the concepts to which the mathematical connections are related. Students' explanations included more superficial relationships rather than specific mathematical concepts, suggesting that the connections made between mathematics and other disciplines are mostly based on the use of the four operational skills.

The students' answers to the open-ended questionnaire question "In your opinion, what kind of benefits will it be for you to connect mathematics with your different courses? Please explain with justifications and give concrete examples" in the pre-opinion form, and the findings obtained by creating codes and categories are presented in Table 6. Before the application, students' opinions on connecting mathematics with different courses were examined. While two of the students did not give answers to the question, one of them gave the answer that it is not useful, and thirty-one of them used various expressions about the benefits of connecting mathematics with other disciplines, but they did not include expressions to support their thoughts. When the opinions on the benefits of connection with other disciplines were examined, twelve students presented their opinions on the contribution of connection as course success. For example, the student E34 stated that "Our success in other lessons will increase even more" while referring to the contribution of the connection to the success of other lessons, while the student E8 stated that it contributes to the success of the mathematics lesson with the statement "It benefits mathematics success".

Table 6

Students' Opinions in the Pre-Opinion Form on Connecting Mathematics with Different Courses

Category	Subcategories	Codes	*f*
Benefits of connection	Contribution to course success	Math achievement, success in different courses	12
	Consolidation of concepts from different courses	Persistence, connection, prior knowledge, topic repetition	12
	Making everyday life easier	Using	2

Similarly, twelve students stated that connecting mathematics with other disciplines would contribute to consolidating the concepts of other disciplines. For example, the student E10 stated that the context of the statement "We are learning concepts about other courses that we do not know, we are learning the relationships between two courses" contributes to the consolidation and permanence of concepts from other disciplines. In the same manner, the student E33 mentioned the same topic with the statement as "It makes it more permanent in the mind. For example, it makes history more memorable in social studies class." Unlike these students, the student E24 stated that connection would contribute to our daily life and make our lives easier with the statement "Of course we use mathematics and other courses in our daily life, which makes our daily life easier". In the same vein, the student E30 mentioned the same topic with the statement "Of course, we use mathematics and other courses in our daily lives. This makes our daily life easier." Unlike these students, the student E14 stated that connection contributes to the interpretation skill with the statement "It allows us to get out of the tests and use our thoughts now, we can make our own interpretations". The student E10, on the other hand, stated that connection would contribute to an entertaining lesson with the statement "I think it makes our lesson more detailed and more fun". The student E30, on the other hand, stated that "We learn more information in a little while" and pointed out that time can be saved with ease of connection. In general, when we look at the students' opinions before the application, it is revealed that the students think that it would be beneficial to connect mathematics with other disciplines. However, considering that many of the students do not explain their thoughts with their justifications, it can be thought that many of the students do not have clear knowledge about connection with other disciplines.

After the application, the students' answers to the open-ended question "Has making a connection between your mathematics course and your courses such as social studies, science, physical education, and visual arts contributed to your interest in mathematics and your success in mathematics? If so, how did it contribute? Please explain" in the final opinion form were subjected to content analysis, and the findings were submitted in Table 7 by creating codes and categories.

Table 7

Students' Opinions in the Post-Opinion Form on Connecting Mathematics with Other Courses

Category	Subcategory	Codes	*f*
The contribution of connection to mathematics	Contribution to math achievement	Open-ended questions, improvement in success	16
	Contribution to interest and motivation	Arousing curiosity, mathematical perspective, feeling happy	7
	Contribution to comprehension skills	Problem solving, thinking skills	6
	Understanding the importance of connection	Relevant course contents, providing subject repetition	3

According to Table 7, thirty-two students gave affirmative answers about the connection of mathematics with other disciplines, but two students did not answer the question. When the answers of the students who gave positive opinions were examined, seven of the students stated that connecting mathematics with other disciplines assisted their interest and motivation in mathematics. For example, the student E23 states that "Yes, I like mathematics more than before because it increased my curiosity by seeing it more in different courses" and states that his interest in mathematics has increased. The student E33, on the other hand, states that connecting mathematics with other disciplines improves his mathematical thinking skills and therefore his self-efficacy belief increases with the expression "Yes, I never thought of other subjects mathematically, but now I feel smarter when I think of them mathematically". Similarly, sixteen of the students think that connecting mathematics with other disciplines contributes to their mathematics achievement. Among these students, the student E15 states that connecting mathematics with other disciplines contributes to the increase in their mathematics grades and their further development, with the statement "Yes, I started to get higher grades, especially in classical questions" as well as the student E14 with the statement "I was already successful, but I think this application improved me more". In addition, six of the students stated that the connection mathematics with other disciplines contributes to their understanding of mathematics and problem-solving skills. The E29 student's opinion, "Yes, I can understand and solve problems better" exemplifies this situation. On the other hand, three students stated that they understood the importance of connecting mathematics with other disciplines with expressions like the statement of the student E33 "It happened, I understood better that every lesson is related to each other". When the opinions of the students after the application process are examined in general, in the final opinion form, the students used clearer expressions in their opinions about the contribution of the connection of mathematics with other disciplines to mathematics. In this case, it can be said that the implementation process assisted the change of students' opinions on connection.

Students' opinions on whether the connection of mathematics with other disciplines contributes to students' interests and achievements in other disciplines are examined in Table 8. While ten of the students stated that making connection did not contribute to other disciplines, twenty-four students stated that connection assisted other disciplines in several ways.

Table 8

Students' Opinions in the Post-Opinion Form on the Contribution of Mathematics' Connecting to Other Courses

Category	Subcategory	Codes	*f*
Contributions of connection to other disciplines	Understanding the importance of connection	Related course content, facilitation	5
	Contribution to success of other disciplines	Grade increase, mathematical solution	6
	Contribution to comprehension skills	Problem understanding, comprehension of course and subject content	6
	Contribution to thinking skills	Mathematical solutions, problem solving, mathematical thinking	6

Six of the students who mentioned the contribution of connection stated that connecting mathematics with other disciplines assisted the increase in success of other disciplines. For example, the student E24 stated that making mathematical solutions would contribute to these lessons for questions related to mathematics in science and social studies lessons with the expression "We were able to apply mathematical concepts to solve problems in both science and social studies, thus making significant contributions to science and social studies during math lessons". The student D34 clearly stated that mathematical connections had a positive effect on his academic performance in other disciplines with the statement "Mathematics contributed more to my success in other courses". Similarly, five students stated that they realized that mathematics and other disciplines assisted each other through connection, and they understood the importance of connection better. For example, the student E20 emphasized the importance of connection with the statement “If the speed and weight of the object were not in science, I could not solve math and science test questions” and stated that it assisted problem solving in mathematics and science. The student E24, on the other hand, emphasized the importance of connection, stating that mathematics assisted other disciplines thanks to the connection with the tasks done throughout the application process, with the statement “Mathematics course assisted science and social studies, since every course was related to mathematics”. Six of the students who mentioned the contribution of the connection stated that the connection assisted comprehension skill. While the student E19 expressed that they better understood the course and subject content of other disciplines with the statement, “Yes, because I can understand the lessons better,” the student E30 indicated that they had a clearer understanding of problems connected to other courses with the statement, “Yes, I understand the problems better.”. Similarly, six students expressed opinions explaining that connection contributes to their thinking skills. For example, the student E14, one of these students, stated that connection with the statement “It happened. For example, I learned which ways I can think and follow mathematically” contributes to his thinking skills and mentioned that his mathematical thinking skills have improved. In addition to these students, the student E6 stated that connection contributes to both other disciplines and daily life with the expression “Mathematics course contributes to us even in daily life”. The findings from the students’ opinions show that connecting mathematics with other disciplines not only increases academic achievement, but also improves comprehension and strengthens thinking skills. When the students’ statements were analyzed after the implementation process, it was found that many students stated that connecting mathematics with other disciplines would make a meaningful contribution to these disciplines; this situation emphasizes the importance of the connecting process in education and enriches the students’ learning experience. Answers of the students to the open-ended questionnaire question “In your opinion, what kind of difficulties or challenges might there be when your mathematics teachers connect mathematics with your subjects such as social studies, science, physical education, visual arts? Explain your opinion with reasons. Give concrete examples” in the post-opinion form were subjected to content analysis and the findings were given by creating codes and categories in Table 9. Before the application, students’ opinions about the difficulties that may be experienced in connecting mathematics with other disciplines were examined. In this question, nine of the students did not answer the question, ten of them stated that the reason for the difficulties to be experienced could be due to the lack of teachers and five of them due to reasons arising from the students.

Table 9

Students' Opinions in the Post-Opinion Form on Difficulties in Connection Mathematics with Other Courses

Category	Subcategories	Codes	*f*
Factors That Make Connection Difficult	No hassle	Relationship between courses, teacher efficacy	11
	Teacher shortage	Lack of information, lack of connection	10
	Student-related factors	Lack of information, concept confusion	5

Eleven students stated that there would be no difficulty in making connections. The student E13 stated that it would be difficult to make connections due to the lack of knowledge caused by teachers of other disciplines in his statement "There would be difficulties in some subjects because other teachers' math was weak". The student E14 stated that a math teacher might have difficulty in connection due to lack of knowledge by using the phrase "Maybe there can be difficulty in explaining the subject if the math teacher does not know much about lessons such as science lessons". Five of the students stated that there may be difficulties in making connections because of reasons for instance deficiency of knowledge and conceptual confusion caused by the students. Among these students, the student E7 stated that teachers might have difficulties in making connections due to the lack of knowledge caused by the students, with the explanation "For example, if we did not know the social lesson, there would be difficulties in the mathematics lesson when the map and area were taught. The teacher would not be able to cover the map and the area." The student E17, on the other hand, stated that the students may experience confusion of concepts and stated that there may be difficulties in making connections with the statement "It happens because one teacher explains, the other teacher says the same, we get confused and have difficulties". Unlike these students, there are also students who think that there is no difficulty in making connections. For example, the student E2 expressed his opinion that there would be no difficulty in connection with the statement "It would not be possible. Because a teacher could sometimes have something stuck in their minds because they read it and tell us.", while the student E22 expressed the same opinion as "I find the science lesson closest to mathematics. Our mathematics teacher explains the science lesson very well. Our science teacher explains mathematics very well". According to the findings from the table, the number of students who stated that there would be no difficulties in making connections between mathematics and other disciplines is higher than those who stated that there would be difficulties. While the majority of students did not see any problems in making connections, some students pointed out that teachers' lack of knowledge and inadequacies in other disciplines could make this process difficult. In addition, a few students highlighted student-induced difficulties due to lack of knowledge and conceptual confusion. These findings indicate that the process of making connections is an issue that needs to be addressed carefully, both in terms of teacher competence and student understanding.

Discussions, Conclusions, and Implications

The findings regarding the quantitative data of the study were obtained by using the mathematical connection self-efficacy scale. According to the before and after the application process, no meaningful difference could be found between the self-efficacy scores for the mathematical connection of the control and experimental group students. Similarly, In addition, within-group comparisons revealed no significant difference between the pre-test and post-test mathematical connection self-efficacy scores for either the experimental or control group. It is possible to see comparable results in studies conducted in literature. Yavuz-Mumcu and Aktaş (2018) found a low relationship between middle school students' ability to connect mathematics with daily life and their self-efficacy in doing so. Additionally, they identified an exceptionally lower-than-expected relationship between students' ability to connect mathematics with other disciplines and their self-efficacy in making these connections. In the study carried out by Hindun et al. (2019) aimed to examine the differences in mathematical connection ability and self-efficacy between control and experimental groups, and the relationship between them. However, their pre-test-post-test study with seventh-grade students found no significant difference in mathematics self-efficacy between the two groups.

In this study, although there was no significant increase in students' self-efficacy beliefs before and after the process, there was a significant improvement in their opinions of mathematical connections. This finding resonates with Kaya's (2020) study, which showed that as perceived teacher emotional support increased, students' self-efficacy difficulties in mathematical connections decreased, while their beliefs in relating mathematics to everyday life and other disciplines increased. Thus, while self-efficacy remained stable in our research, the qualitative improvement in students' perceptions of mathematical connections suggests a similar influence of supportive factors. In his study with pre-service teachers, Zengin (2019) concluded that learning concepts by creating materials in the GeoGebra application meaningfully increased self-efficacy for mathematical connection of pre-service teachers. When reviewing the studies in the literature, it is possible to come across studies where there is no significant increase in self-efficacy beliefs about mathematical connections as well as studies where there is an increase. In this study, although there was no significant increase in students' self-efficacy beliefs before and after the process, positive developments were observed in students' views of the mathematical connection. This may be because the qualitative improvement in students' self-efficacy beliefs about mathematical connections and their views on mathematical connections is influenced by many supportive factors, such as the emotional support of the teacher (Kaya, 2020).

The positive effects of mathematical modelling processes on students' mathematical connecting skills are often highlighted in the literature. Duman and Aydoğan Yenmez (2024) state that, in addition to students' use of interconnection skills between concepts and real-world connection skills in mathematical modelling processes, these processes enable them to make connections between different disciplines and different representations of concepts, thus enhancing their connection skills. Similarly, Czocher et al. (2019) argue that teaching processes based on mathematical modelling have a high potential to develop self-efficacy for disciplines such as science, engineering, and mathematics courses. In this context, modelling activities are found to not only strengthen mathematical connections, but also increase students' self-efficacy beliefs. Takaoğlu (2015), in his study investigating the relationship between connections in physics courses using mathematical modelling and pre-service teachers' interests, found that these modelling activities contributed to pre-service teachers' better understanding of the relationships between physics and mathematics and everyday life in interdisciplinary connections. These findings suggest that modelling activities play an important role in developing students' interdisciplinary connection skills. Finally, studies of mathematical modelling in the context of making connections between different disciplines show that it contributes to participants beyond the regular curriculum (English, 2007). These studies support the idea that integrating mathematical modelling into educational processes can increase the potential for improving students' self-efficacy beliefs and connection skills. Indeed, in the experimental process carried out with the mathematical modelling process in our study, it is seen that students' views on mathematical connectedness emphasize the importance of the connectedness process and enrich students' learning experiences.

At the beginning of the study, it was observed that students' awareness of the connections between mathematics and other disciplines was limited. In addition, it was observed that teachers of other subjects such as social studies, science, physical education, visual arts, etc. did not mention the topics and concepts of mathematics while teaching mathematics-related subjects, and therefore students could not think about making connections with the topics and concepts of mathematics. An analogous situation was also found in the studies of Coşkun (2013) and Özgen (2013a, 2013b). In Coşkun's (2013) study, it was concluded that teachers mostly made connections between concepts and daily life, but almost no connections with other disciplines. In Özgen's (2013b) study conducted with pre-service teachers, it was observed that the participants could not make connections within mathematics at the desired level, and the connections with other disciplines and daily life remained at extremely low levels. Similarly, Özgen (2013a) concluded in his study with pre-service teachers that although pre-service teachers had opinions about the connection with other disciplines and the connection of mathematics within itself, it was at a limited level. Considering the studies in the literature, it can be said that participants have limited opinions about the types of mathematical connections before a specific application for mathematical connection is made. In addition, it can be said that students' views are also limited because teachers do not do enough work to connect them to other disciplines.

At the end of the process, the study found that students in the experimental group were more positive about making connections, had a better understanding of the importance of connections, and stated that interdisciplinary connections contributed to their success in mathematics and other courses. It was also found that almost all students stated that connecting mathematics with other disciplines increased their interest and motivation in mathematics. In addition, students stated that connecting mathematics to other disciplines in this context improved their higher order thinking skills and enabled them to better understand concepts in different disciplines. This change in perspective shows that the application process plays an important role in developing more positive attitudes towards mathematical connections. Students' better recognition of interdisciplinary connections highlights the success of the intervention in increasing their understanding and interest in mathematics. This suggests that both mathematics teachers and teachers of other disciplines should enrich their course content to make interdisciplinary connections. In addition, it is predicted that longer-term interventions that focus on interdisciplinary connections can improve students' self-efficacy beliefs at a more significant level.

The positive effects of connecting mathematics with other disciplines on interest (Başkan Takaoğlu, 2015), motivation (Domínguez et al., 2015), retention (Deveci, 2010) and achievement (Dorn et al., 2005; Parr et al., 2009) have also been highlighted in the literature. For example, Sandalcı (2013) aimed to investigate the effect of mathematical modelling on middle school students' academic achievement and ability to relate mathematics to daily life and found that even students with moderate and low achievement increased their interest during discussions and improved their understanding. Domínguez et al. (2015) conducted an integrated course study of mathematics and physics with undergraduate students and found that participants' motivation increased and their skills, such as critical thinking and collaboration, improved.

According to the quantitative findings of the study, no significant difference was found in the 'difficulty' dimension of the mathematical relevance self-efficacy beliefs scale. However, the qualitative findings showed that students' beliefs about the difficulty of making mathematical connections decreased after the process. In particular, most of the students in the experimental group stated that there was no difficulty in making connections between mathematics and other disciplines at the end of the process. In the study conducted by Sandalcı (2013) with secondary school students, it was found that the students' ability to see the connection between real life and mathematics improved and that the difficulties experienced by the students at the beginning decreased over time. This shows that the activities used in the teaching process can have a positive effect on students' ability to make connections, but these activities should include more guidance in terms of accessibility.

When the qualitative and quantitative data of the study were analyzed separately, it was found that the modelling tasks prepared in the context of connections with other disciplines and the learning environment designed did not produce a statistically significant difference in students' beliefs about their self-efficacy in mathematical connections. However, positive developments were observed in the views of students in the experimental group regarding their connections with other disciplines. Another important finding is that although students had limited awareness of making interdisciplinary connections at the beginning, this awareness increased after the implementation process. Students stated that making mathematical connections not only increased their success in the course, but also increased their interest and motivation in mathematics. This change shows that the modelling activities were successful in developing students' awareness of mathematical connections. These results suggest that mathematical connections should be emphasized more in future teaching processes. Future studies can focus on long-term applications to make these connections more permanent and to further support students' self-efficacy beliefs.

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Conflicts of Interest

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

Author Bios:

Zülküf Kılıç: He completed his master's thesis in Mathematics Education at Dicle University, Department of Mathematics and Science Education. He is preparing his Ph.D. thesis in Mathematics Education at Dicle University Mathematics Education Doctoral Program, which he started in 2022. His research focuses on teacher education, mathematical modeling, task development, mathematical connections and problem solving.

Kemal Özgen: He is a professor at the Department of Secondary Science and Mathematics Education, Department of Mathematics Education, Ziya Gökalp Faculty, Dicle University. His research focuses on problem solving and posing, task development, mathematical connections, and mathematical literacy.

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Appendix-1: Sample Modelling Task and Daily Lesson Plan

Course	Mathematics Applications Course
Class	Seventh Grade
Duration	80 min.
Learning Areas	Geometry and Measurement; Numbers and Operations; Algebra
Sub-Learning Areas	Measuring Length, Ratio, Linear Equations
Skills	Modelling, problem solving, relating, communication, reasoning
Methods And Techniques	Mathematical modelling, question and answer, problem solving, brainstorming, discussion, estimation strategies, presentation, lecture
Outcomes Related to The Mathematics Course	**5.2.3.1.** Recognizes the units of length measurement; Converts meter-kilometer, meter-decimeter-centimeter-millimeter units and solves related problems. **6.1.6.1.** Uses ratio to compare multiplicities and displays ratio in different ways. **7.2.2.2.** Expresses how one of two variables, which have a linear relationship between them, changes depending on the other, with tables, graphs, and equations. **M.U.7.1.4.1.** Solves problems related to direct or inverse proportion.
Outcomes Related to The Related Course(S)	**<u>Visual arts</u>:.6.1.5.** Uses perspective in visual artwork. Uses line perspective to create the effect of depth in space. **<u>Social studies</u>: 6.2.7.** Realizes the interaction between the settlement and economic tasks and social structures of the first civilizations that lived in Anatolia and Mesopotamia.
Tools	Worksheet, interactive whiteboard, video clip.
Objective Of the Task	The purpose of this modelling problem is to enable students to make connections between mathematics, visual arts, and social studies lessons. It is aimed for the student to establish a relationship with the social studies course by giving articles about historical places. Thus, to have information about historical textures, it is aimed to direct students to research by arousing their curiosity. In addition, the purpose of the expression "Assuming that the people in the photograph and the Keci Bastion are at the same distance" in the problem sentence, the students are expected to make a connection between the depth and perspective topics in the space in the visual arts lesson and the ratio-proportion topics in mathematics. Because perspective and proportion are naturally related in painting (Kabakçı & Demirkapı, 2016). In addition, the purpose of choosing the modelling problem is to realize that the subject of perspective and the ratio-proportion are related, and to realize that the ratio exists in the photographs and pictures that they will encounter in daily life.
Application Process of The Task	After the students are divided into upper, middle, and lower groups according to their first semester math report grades, they will be divided into groups of three, one from each level. The following preparatory questions will be given to the students from the previous week before the task and they will be asked to prepare assignments. During the preparation phase, students will be asked to present their assignments in the form of boards and presentations. Afterwards, the part of the video clip "Diyarbakır Walls on the Way to UNESCO" video clip prepared by the Diyarbakır Metropolitan Municipality will be shown to the students by the teacher, and the students will be drawn to the event. Then, "Keci Bastion" worksheets will be distributed to the students, and they will be asked to read the reading passage of the task and focus on the photograph. By brainstorming in the class about the sub-directions developed for modelling competencies in the task, the parts that are not understood will be tried to be found by the teacher with questions. After the sub-directions developed for modelling competencies are discussed step by step with the class, students will be given time to write their thoughts and solutions on the worksheets as a group.

Preparatory Work (20 Minutes):

Presentations of the students regarding the research topics given from the previous week are taken on the board work and homework. Studies are conducted for the readiness of the students.

- Make research on the Turkish-Islamic civilizations that ruled in Diyarbakır and turn it into a panel study.
- Do general research on the Diyarbakır Walls.
- What is "perspective" in Visual Arts? Please search.
- Explain the concept of ratio-proportion in mathematics. What is its relationship with the concept of "perspective" in the Visual Arts course? Please search.
- If the length of 1 cm on a map is 1 km, how many km is a line segment with a length of 10 cm on the same map?
- Investigate length measurement units.

Task Application (40 Minutes):

Worksheets will be distributed, and the problem will be solved in accordance with the steps.

The Keçi Bastion

In the photo above, a part of the Keci Bastion is seen on the hewn rock mass east of the Mardin Gate of the Diyarbakır city walls. The Keci Bastion is the oldest and largest of the bastions on the walls. There is an inscription on the bastion, whose exact date of construction is unknown, indicating that it was repaired by Mervanoğlu in 1223.

Mr. Ahmet, reading the information about the Keci Bastion above, wants to calculate the approximate height of the Keci Bastion. If we assume that the people in the photo and the Keci Bastion are at the same distance, can you help Mr. Ahmet to calculate the height of the Keci Bastion?

1) Interpret what is given to you and what is asked of you by expressing the problem in your own words.

2) Make up your own assumptions about the problem.
3) Explain how you will follow a mathematical path in solving the problem.
4) Solve the problem according to your assumptions.
5) Write your comments on the result of your solution.
6) Verify your solution.
7) What do you think is the relation of this problem with your following lessons? Please explain.

- Relationship with social studies:
- Relationship with visual arts:

Evaluation Study (20 Minutes):

After the worksheets are collected, students in separate groups will be asked to make a presentation about the solution of the task for the modelling problem. Then, in the presentations made about the task, questions such as "Can you follow a different way", "Why did you solve this way" and "Can you explain the reason for your solution" will be directed by the teacher in order to produce different solutions, sub-directives developed for modelling competencies in the task. In addition, various pictures will be shown by the teacher and a relationship will be made with the perspective subject of the visual arts lesson.

Example Solution of the Modelling Problem:

1) Understanding the problem

The height of the Keci Bastion, which is at the same distance in the photo, is proportional to the height of the people.

2) Simplifying the problem and making assumptions about the problem

In the problem, we are asked to find the height of the people and the Keci Bastion by ratio.

Assuming that the average human height is 170 cm = 1.7 m

Assuming the height of the Bastion is about ten times the height of humans

3) Mathematizing

The correct proportion is established so that: $\frac{\text{average human height}}{\text{height of the Keci Bastion}} \cong \frac{1}{10}$

4) Mathematical working

$\frac{\text{average human height}}{\text{height of the Keci Bastion}} \cong \frac{1}{10}$

Also, if we say x to Keci Bastion's height,

from the equation $\frac{\text{average human height}}{\text{height of the Keci Bastion}} \cong \frac{1}{10} = \frac{1{,}7}{x}$

If 1.x=10.1,7m with the product of the insides and the outsides,

the length of Keci Bastion (x) =17 m.

5) Interpretation

After the assumptions were created in the solution, the height of the Keci Bastion was calculated. It can be understood that the sizes of objects located at the same distance in photographs and pictures are proportional.

6) Validating

Since we assume that according to the photograph, the average human height is equal to ten times the height of the Keci Bastion, the result is accordingly correct.

7) Connection between outcomes

Social studies: Since the article given to the students mentions the history of Anatolia and Mesopotamia, it has a connection with the social studies course. In addition, students are expected to realize the importance of our cultural values.

Visual arts: In the content of the problem, a connection was established between the concept of perspective in visual arts and the concept of ratio in mathematics. The students are expected to state that if the distances of the Keçi Bastion and the people in the image to the camera are equal, the heights of the Keçi Bastion and the people are proportional.