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Abstract

Interdisciplinary approach recommended for use in the teaching mathematics in the last decade, the related literature shows that limited study focused on the reflection of the interdisciplinary approach in teaching practice. The aim of this study is to evaluate pre-service mathematics teachers' task development processes on interdisciplinary approaches through building and coding tasks. Research was conducted with 28 pre-service mathematics teachers studying at a mathematics education department in Turkey. Data were gathered from the analysis of lesson plans and semi-structured interviews. The findings that were obtained through the lesson plans of the participants indicated that participants were able to associate building tasks more with numbers content domain and mathematical modeling skills, and coding tasks with geometry content domain and algorithmic thinking skills. The participants stated that tasks involving coding in their lesson plans would be more useful in terms of teaching mathematics and listed the factors limiting the use of building tasks as technical knowledge and cost.

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Research Article

Examining the Building and Coding Tasks Developed by Pre-service Mathematics Teachers in Terms of Curriculum Integration*

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Abstract

Interdisciplinary approach recommended for use in the teaching mathematics in the last decade, the related literature shows that limited study focused on the reflection of the interdisciplinary approach in teaching practice. The aim of this study is to evaluate pre-service mathematics teachers' task development processes on interdisciplinary approaches through building and coding tasks. Research was conducted with 28 pre-service mathematics teachers studying at a mathematics education department in Turkey. Data were gathered from the analysis of lesson plans and semi-structured interviews. The findings that were obtained through the lesson plans of the participants indicated that participants were able to associate building tasks more with numbers content domain and mathematical modeling skills, and coding tasks with geometry content domain and algorithmic thinking skills. The participants stated that tasks involving coding in their lesson plans would be more useful in terms of teaching mathematics and listed the factors limiting the use of building tasks as technical knowledge and cost.

Keywords: Building task, coding task, curriculum integration, teacher education

1. INTRODUCTION

Determining the factors that affect the learning and teaching of mathematics is at the forefront of mathematics education research. There is a growing literature in task design and implementation, including problem situations, exploratory methods, and activities to promote student learning (Anderson, 2003; Chapman, 2013; Clarke & Roche, 2010; Leung & Bolite-Frant, 2015). The type of task and the way it is used in the classroom context widely determines the quality of student learning. Tasks play an important role in organizing the teaching environments and act as mediators between the students and the knowledge presented in the learning environment. The tasks help in activating and controlling the learning environment and processes in order to facilitate effective and quality learning (Stein, Grover, & Henningsen, 1996). Besides, tasks stimulate students' reactions to the learning material, allowing them to deal with the topic intensively. When mathematical tasks are presented in the form of activities, opportunities emerge to help students develop skills such as mathematical thinking, reasoning, modeling and interpretation in the learning, teaching environment and processes of mathematics (Stein, Grover, & Henningsen, 1996).

Development of prospective mathematics teachers' skills of task design for effective teaching is an important goal in teacher education programs, given that mathematical tasks ‘‘provide the stimulus

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for students to think about particular concepts and procedures, their connections with other mathematical ideas, and their applications to real-world contexts'' (National Council of Teachers of Mathematics [NCTM], 1991, p.24). Teachers' mathematical task knowledge for teaching (Chapman, 2013) appeared to be a major contributing factor in their choice of tasks in the classroom (Anderson, 2003). There is evidence that pre-service and in-service teacher training has a prominent role in the development of teacher task choice and task design capacities (Clarke & Roche, 2010). It is imperative that pre-service mathematics teachers have mathematical proficiency in the major mathematical domains; they are responsible to teach (NCTM, 2020). This proficiency needs to be demonstrated within mathematics as well as across other disciplines. Ability to design interdisciplinary instruction and to be engaged in interdisciplinary conversations are important elements of effective mathematics teaching (Association of Mathematics Teacher Educators [AMTE], 2017; NCTM, 2020). A mathematics teacher should be competent in how the knowledge of other disciplines are used in their mathematics teaching as well as how mathematics is used in other disciplines. In mathematics lessons, mathematics needs to be given the leading role within an interdisciplinary teaching approach. An interdisciplinary approach in teaching mathematics gives significant attention to the learning of mathematics and promotes the use of hands-on activities that link to real world problems (Ostler, 2012). A particular consideration in the development of pre-service mathematics teachers' ability to design an interdisciplinary mathematics lesson is that which topics can be taught in an interdisciplinary approach) so that students can have significant gains. There is a degree of suitability of the content taught for an interdisciplinary teaching for that the learning goals for teaching mathematics is sufficiently addressed (Ministry of National Education [MoNE], 2018; NCTM, 2020).

Our intention, in the present study, is to understand, in the eyes of the pre-service mathematics teachers, which parts of the mathematics curriculum are suitable to be used in an interdisciplinary approach. Thus, we aim to understand how much pre-service mathematics teachers can observe mathematical skills in tasks that require establishing links to other disciplines. This particular work is part of a bigger project supported by the Scientific Research Project Committee at Marmara University. Our wider focus, as defined in that study was to investigate the ways in which mathematics is taught in an interdisciplinary approach. In this particular study, we pay attention to the role of the tasks within this integration process. Trying to look at the issue from the eyes of the pre-service mathematics teachers, we intend to investigate two issues which lead to the following research questions:

1) What content domains and skills do pre-service mathematics teachers focus on when developing interdisciplinary tasks?

2) What are the views of pre-service mathematics teachers regarding the usefulness of the developed tasks in the mathematics teaching process?

With the answers to the research questions mentioned above, it will examine the views of pre-service mathematics teachers on the usefulness of two types of tasks in the STEM (an acronym for Science, Technology, Engineering, and Mathematics) field, who are future STEM content practitioners. In addition, it is aimed to fill the gap in the literature by focusing on the mathematical skills that are aimed to be developed in the integrated STEM curriculum.

1.1. Conceptual Framework

1.1.1. Mathematics in interdisciplinary approaches

How to apply interdisciplinary approach and how to adapt it to existing education systems is an important issue. Studies have shown that students are more motivated and perform better in mathematics when teachers use an interdisciplinary education approach (Becker & Park, 2011; Yıldırım & Altun, 2015). In their meta-analysis studies, Becker and Park (2011) explained that the integrated teaching approaches have positive effects on learning. This positive evidence from inside the classroom revealed the importance of developing mathematics teachers' interdisciplinary teaching practices within the in-service and pre-service teacher training processes. The teacher education literature shows promising findings of the influence of programs or modules that are incorporated into the existing mathematics and science teaching curricula on pre-service teachers' readiness to use the interdisciplinary approach in the classroom. Bracey and Brooks (2013) asserted that the pre-service teachers' self-efficacy, interests and attitudes towards science were improved at the end of a collaborative program that aimed to increase the competence and skills of pre-service teachers in teaching concepts related to science, technology, engineering and mathematics. There were positive correlations between the perceptions of participant teachers about their integrated teaching competencies, their inquiry-based practices and feeling comfortable about integrated teaching (Nadelson, Seifert, Moll, & Coat, 2012). Likewise, at the end of the program that aimed to increase the engineering and design knowledge of teachers, the participant teachers improved their integrated teaching skills and continued to develop their skills (Pinnell et al., 2013). As a result of the practice of integrated approaches and engineering practices into teachers' science laboratory classes, Yıldırım and Altun (2015) found positive effects on student achievement. Çorlu, Capraro and Çorlu (2015) explored the mental readiness of pre-service teachers to facilitate integrated mathematics and science. Results indicated that pre-service mathematics teachers in the integrated teacher education program had more favorable attitudes towards integrated teaching of mathematics than pre-service mathematics teachers in the departmentalized program. After the integrated teaching focused workshop, pre-service science teachers were reported to have started to use technology and engineering besides mathematics in natural sciences teaching (Çınar, Pırasa, Uzun, & Erenler, 2016). In another study, the positive effect of a collaborative STEM education module on pre-service chemistry and mathematics teachers was reported (Aslan-Tutak, Akaygün, & Tezsezen, 2017). All these studies reveal that it is important to understand and develop the interdisciplinary relations of mathematics from the perspective of pre-service or in-services teachers.

The most agreed upon classification about different disciplines working together is the three level hierarchies which differentiates the level of cooperation with respect to the degree of interweave of the contributing disciplines. While solving a problem, multidisciplinary approach involves little interaction across disciplines in which each discipline contributes with their own viewpoint. In multidisciplinary approach component boundaries start to break down and disciplines work together in such a way that each discipline can affect the research output of the other. In transdisciplinary work, a holistic approach is formed in which the cooperation leads to the foundation of a new discipline (Niculescu, 1998). The multidisciplinary approach entered into educational research literature widely with the STEM education movement.

STEM education approach appears as a system that connects Science, Mathematics, Engineering and Technology with each other. In this system, students use engineering design, mathematical thinking and modelling, technological literacy and scientific inquiry skills in order to advance STEM-related studies (Topçu & Gökçe, 2018). According to Yıldırım (2018), in order for a study to be called STEM, it must include all four disciplines which have defined roles. The integration of the disciplines within the context of a complex real-life question, the problem of the level and visibility of mathematics may arise. That is, the role of mathematics is reduced to a computational tool. While some of the integrated teaching approaches used in mathematics teaching can be labelled as a "STEM education approach" (Çorlu, 2017), the fact that different interpretations of the "STEM education approach" were made in the fields of mathematics and science over time emerged as an issue. In terms of science education, while the classical definition does not cause a problem in classroom practices, this classical definition is restrictive for mathematics education (due to the restriction of the role assigned to mathematics).

We prefer to use the "interdisciplinary mathematics teaching approach" instead of "STEM education" for the approach used in this study, as; we believe that it fits better to our research purpose. According to Jacops (1989), interdisciplinary teaching is the deliberate coming together of more than one discipline in relation to a concept, phenomenon or problem which is compatible with the holistic natural thinking structure of human beings. Mathematics, used in interdisciplinary teaching is the centre of interest during its coexistence with other disciplines. That way, the role of mathematics cannot be limited to being used as a computational tool and the language provider. In interdisciplinary mathematics teaching, mathematics solves the multi-faceted real-life problems by establishing relationships with other disciplines with its own method, technique and knowledge, at the core. However, when it comes to STEM education, there are pre-defined for each of four components (e.g. engineering-oriented design processes are visible, technology plays its own part, mathematics feeds and connects these related disciplines by providing the "language" and computational support) (Topçu & Gökçe, 2018). Furthermore, while STEM education conceptually is limited to four disciplines, there is no such restriction in interdisciplinary approach. There is also no pre-acceptance about the central discipline in interdisciplinary teaching, and the discipline using this approach is at the forefront. For example, mathematics is at the centre in interdisciplinary teaching and that the other disciplines can have auxiliary roles.

1.1.2. Mathematics education and coding

Coding has become a basic requirement along with mathematics due to the need in today's digital world. In the many curricula worldwide, there is particular attention given to developing coding skills, with evidence of its influence on the skills of logical thinking and problem solving (Balanskat & Engelhardt, 2014). It is pointed out in the literature that coding education contributes to the development of many skills of students such as analysis, problem solving, generalization, and algorithmic thinking (Michael & Omolove, 2014). In mediums that can be coded with ready-made code blocks such as Scratch, students can design their own games and animations. Along with the algorithmic thinking and number pattern knowledge required in coding, it has brought the idea that "may coding approach be used to support mathematics teaching?" There are various studies showing that coding education contributes to mathematics education in cognitive and/or affective sense (Balanskat & Engelhardt, 2014; Forsström & Kaufmann, 2018; Lewis & Shah, 2012; Özdemir, Sevimli, Aydın, & Derin, 2018; Taylor, Harlow, & Forret, 2010). In their study, Lewis and Shah (2012) revealed that coding motivates students positively when studying mathematics and positively affects academic performance. Similarly, it has been shown that coding has positive effects on students with weak mathematical thinking skills (Taylor et al., 2010). Forsström and Kaufmann (2018) found that coding has positive effects on student motivation, mathematics performance, the cooperation between students, and the role of the teacher in learning mathematics. Özdemir, Sevimli, Aydın and Derin (2018) observed in their study with pre-service mathematics teachers that the participants defined their coding tasks as a visualization tool that can concretize algebraic expressions in mathematics courses. There is evidence that the skill of coding contributes to the learning of mathematics (Aydın, Sevimli, Özdemir & Derin, 2019). For example, it was used to enhance the understanding of the concepts of applied mathematics such as algorithm, iteration, and variable. With coding programs, students can make some abstract mathematical concepts visible. Students learn such concepts better by turning mathematical ideas into games and animations (Gadanidis, 2015). As well as accustoming students to coding, the purpose of using mediums such as Scratch in class may be the development of other skills such as analysis, algorithmic thinking, concretization, and computational thinking skills rather than teaching the coding itself (Calao, Moreno-León, Correa, & Robles, 2015).

Since the positive effect of coding on mathematics teaching and 21st century skills are supported by research, coding contents have become more visible in K-12 curriculum. Sayın and Seferoğlu (2016) noted in their study that some countries that add coding to their curriculum (eg:

England, Finland, and Australia) set it out on the grounds of "supporting logical thinking" and "supporting problem solving". In another study, Hubwieser et al. (2015) investigated the objectives of countries for including coding in their curriculum by examining not only Europe but a wider geography. It can be observed in this study that there is a direct or indirect relationship between mathematical skills and coding. Although there are various recommendations for disciplines where coding is useable, there is little consensus on how to include coding in the school curriculum or whether it should be integrated into the curriculum (Grover & Pea, 2013). For example, England, Denmark and Sweden have integrated coding into mathematics but further discussion is needed on how programming could be linked to other subject areas and to what extent it would affect students' performance (Bråting & Kilhamn, 2022). Along with the integration type in the curriculum (in which course and with which learning outcomes), the evaluation of coding in terms of teaching practice is also an important need. The present study is important in that it extends our knowledge about pre-service mathematics teachers' task type choices (building and coding) and task design practices in terms of interdisciplinary approaches.

2. METHOD

The case study design was used to evaluate the process of the participants in a specific learning environment in depth. This research was conducted with 28 pre-service mathematics teachers studying at a mathematics education department in a state university in Turkey by purposeful sampling. Participants had high class participation with teamwork and they were involved in teaching practice in secondary schools. Besides, participants have been selected from among pre-service teachers who took the "interdisciplinary mathematics teaching" elective course at higher education level. During the autumn semester of the 2018-2019 academic years, the participants were faced with modeling tasks under this course in the mathematics laboratory. We considered this as an opportunity to investigate our research question.

2.1. Interdisciplinary Mathematics Teaching Course

The aim of this higher education level course is to explain how to improve 21st-century skills theoretically and practically by associating mathematics disciplines' learning outcomes with other disciplines in mathematics teacher training program. Two hours every week, the course lasted for 16 weeks and participants spent 32 hours in this course during a semester. The course consists of four stages. During the course, a problem-based teaching approach has been used and the considered process has been expressed in Table 1.

Table 1. Interdisciplinary mathematics teaching course stages

Number and hour	Stage name	Stage content
1st Stage: 8 hours	Modeling task	Ferris wheel problem Real estate problem Parking lot problem Paper bridge problem
2nd Stage: 8 hours	Building tasks	Propeller and gear system Bridge problem Crane problem Ferris wheel problem
3rd Stage: 8 hours	Coding tasks	Mblock training Microbit training Scratch training
4th Stage: 8 hours	Task development	Preparation and presentation of lesson plans

In the first stage of the course, participants have been asked to solve the problems given by using the mathematical modeling approach with paper and pencil. It was aimed to contribute to the mathematical modeling skills of prospective teachers in this way. Thus, students were encouraged to use hands-off mathematical modelling tasks in preparation for the next stage in which hands-on STEM building tasks were used.

In the second stage of the course, participants were introduced to the tasks developed using mechanical STEM building sets (plug-in parts). Hence, the transition from paper and pencil-based problems to applied problems using engineering building blocks sets has been made. Building blocks engineering sets and tasks used in applied problems are the following: Propeller and gear system (static sets), bridge problem (static sets), crane problem (dynamic sets), Ferris wheel problem (dynamic sets) and wind turbine problem (robotic sets). Fischertechnik sets and similar sets are used in the studies conducted in the context of interdisciplinary mathematics teaching (Özdemir et al., 2018; Yıldırım & Altun, 2015). These tasks include quantitative reasoning, problem-and-project based learning.

In the third stage of the course, participants who have not learned any coding language before have been trained to use programming languages such as Microbit, Mblock and Scratch. The reason for choosing these coding languages has been the consideration that they will contribute to the building of algorithmic thinking skills. In addition, the fact that these programming languages are widespread throughout the world, they are easy to use, they are suitable for student levels and they are offered free of charge to everyone, has been an important factor in the selection of these programs.

In the last stage of the course, students have been asked to prepare and present task-based lesson plans in light of what they have learned during the whole course process. Tasks developed by using mechanical STEM building sets are coded as building tasks. The coding task is defined as a task in which students are required to use coding software.

2.2. Data Collection Tools and Analysis

Research data were collected from two sources, which are lesson plans and interviews. After the "interdisciplinary mathematics teaching" course, participants were expected to develop two types of tasks (building and coding tasks). Thereafter, participants were asked to present these tasks in lesson plans. During preparation of lesson plan, the researchers divided the class into groups of four, and the participants have been expected to develop a building and a coding task that could be used in mathematics education using the materials included in the STEM building sets and using Scratch, respectively. Data in lesson plans were analyzed through content analysis technique. The lesson plans content were analyzed with respect to the two predefined themes such as content domains and mathematical skills.

While classifying according to the content domain, the categorization made by The Trends in International Mathematics and Science Study (TIMSS) in 2019 was used (Mullis, Martin, Foy, Kelly & Fishbein, 2020). According to this categorization, 8th-grade mathematics contents consist of the following four domains (and topics): "Number" domain (integers, fractions, decimals, ratio, proportion, and percent), "Algebra" domain (expressions, operations, equations, relationships, and functions), "Geometry" domain (geometric shapes and measurements), and "Data and Probability" domain (data display and probability). After the tasks developed by the participants were classified according to the content domain, the compatibility of each task with the curriculum was evaluated. In the evaluation process, all participants scored each task between 1 and 5 points (1 = totally incompatible -- 5 = totally compatible) according to the criteria of being compatible with the learning outcomes in the mathematics curriculum, and the average of all scores for each content domain was calculated in percentage. In the categorization process of mathematical skills, the skills highlighted in the secondary school level of mathematics curriculum in Turkey were taken as reference (MoNE, 2018). Thus, the tasks in the lesson plans were coded under categories such as algorithmic thinking, modeling, reasoning, and visualization in terms of the mathematical skills to be achieved. After determining the content domain and mathematical skills that the tasks included, tasks were analyzed descriptively in terms of frequency and percentage.

The second source of data was the views of the participants, which were collected through the semi-structured interviews. Some of the participants were selected by means of purposeful sampling technique and the points that were taken into consideration during the preparation of the lesson plans were analyzed more deeply. Excerpts from participants' views were used to support the trends revealed from the lesson plans. The data came from the interviews which were collected as part of formative assessments of the course. The tasks in the course presented a fruitful opportunity in that regard.

2.3. Validity and Reliability

The validity and reliability processes in the present study were provided by long-term interaction with the participants, coding the data by inter-raters, and benefitting from the categorization framework of the institutions (MoNE, 2018; Mullis et al., 2020) in data analysis. Incorporation of the data from two data sources (i.e. the lesson plans and the questionnaire), have been the primary precaution to increase the validity of the findings. The analysis of the validity of the questionnaire data was carried out by the independent controls of four researchers. They evaluated the questions in the questionnaire for correct comprehensibility. Data analyzes were done collaboratively by the authors. Data from each of the lesson plans that were analyzed by one of the researchers was checked by another researcher to prevent possible misinterpretations. The randomly selected 9 lesson plans were coded by two more external raters (mathematics teachers), and between these and the authors' encodings, a consistency between 85% and 94% was found. The codes that did not reach a common understanding among the external raters were reviewed together by the researchers and a consensus was reached. For example, one rater referred to modeling and another rater referred to reasoning as the mathematical skill to be developed in Task-18. After the meeting of the researchers, it was evaluated that this code could be included in both categories. Since the opinions on compatibility with the curriculum were obtained directly from the participants, there was no problem in terms of coding accuracy.

3. FINDINGS

Findings obtained through the analysis of lesson plans focused on building and coding tasks developed by the participants are presented under two headings: content domains in developed tasks and mathematical skills in developed tasks. As a result of supporting these findings with the interview data carried out with the participants, views regarding the usefulness of building and coding tasks in the learning-teaching process were determined and presented under the heading "the usefulness of the tasks in the teaching process".

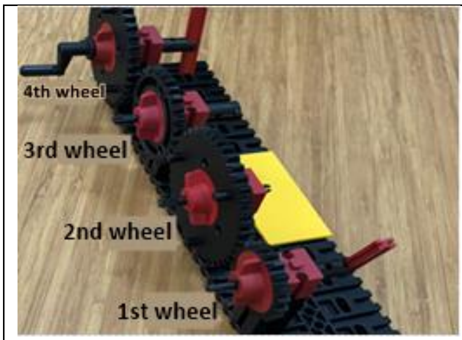
3.1. Content Domains in Developed Tasks

Each participant has prepared a lesson plan for each type of tasks (building and coding) for applying these tasks to one of the content domains at the secondary school mathematics level. All developed tasks have been examined and the findings that show the distribution of tasks by content domain have been presented in Table 2. It was found that in lesson plans focused on building task, half of the participants (*f = 14*) developed tasks for "Numbers" content domain, followed by "Data and Probability" (29%) and Geometry" (21%) domains, respectively. One of the remarkable findings has been the fact that none of the lesson plans prepared by the participants included any building task for algebra content domain. It was observed that the participants who prepared a lesson plan focused on coding task preferred the content for geometry content domain more frequently (71%). Another content domain that has been used more frequently after the "Geometry" content domain among coding tasks has been algebra (21%). It is noteworthy that for the "Numbers" and the "Data and Probability" content domain, being one for each, only two coding tasks have been developed.

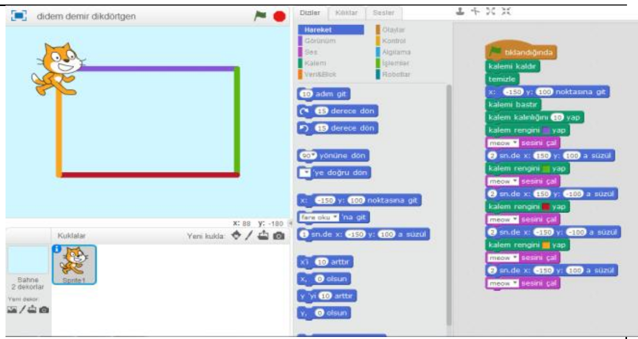
Table 2. Distribution of tasks by content domain and curriculum integration

Content domain		Number of tasks		Compatibility with the curriculum
		f	%	%
Building tasks	Numbers	14	50	73
	Algebra	-	-	-
	Geometry	6	21	56
	Data and Probability	8	29	51
Coding tasks	Numbers	1	4	65
	Algebra	6	21	53
	Geometry	20	71	87
	Data and Probability	1	4	48

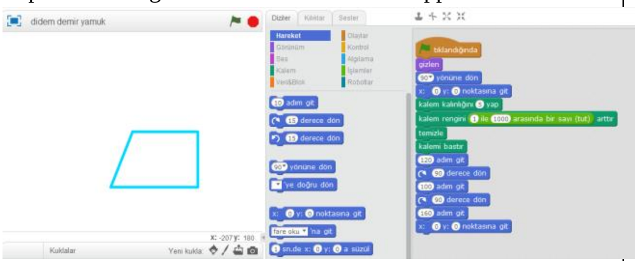
After the developed tasks were classified according to the content domain, each participant was expected to evaluate each task in compatibility with the curriculum integration. It was observed that some of the task types used in lesson plans were preferred more frequently for some content domains. According to this, the participants evaluated building tasks in numbers content domain more useful for achieving learning outcomes in curriculum (73%). Approximately half of the participants do not have a positive opinion on the integration of building tasks developed in other content domains into the curriculum. In addition, coding tasks were found more useful for achieving learning outcomes in the geometry content domain. In this regard, 83% of the participants stated that the coding tasks in the geometry domain could be integrated with the curriculum.



Create a wheel system that satisfies the conditions given below and is compatible with the model in the picture. When the first wheel turns 4 full turns, the fourth wheel turns 1 full and a half turn,
-Compare the number of laps of the wheels.
-Find the radii of the wheels.
-Compare the direction and speed of the wheels.



Interpret the edge-angle differences between the square and trapezoid through the codes in the Scratch application.



Building task | **Coding task**

Figure 1. The building and coding task of participant-4

In building tasks-based lesson plans, more than half of the participants (nine of the 14 participants) who prepared suitable content for the numbers content domain prepared content for the teaching of the ratio and proportion subject using wheel systems of simple machines. One of the tasks that Participant-4 developed is given in Figure 1. It aims to express the relationship between two multiplicities that are directly proportional and inversely proportional with the help of the number of turns and direction of rotation of the wheels of different radii. For the geometry, Participant-4 used coding tasks to compare the properties of triangles or quadrilaterals and to show their hierarchical relationships by experiencing. One of the tasks utilized in this context is presented in Figure 1.

3.2. Mathematical Skills in Developed Tasks

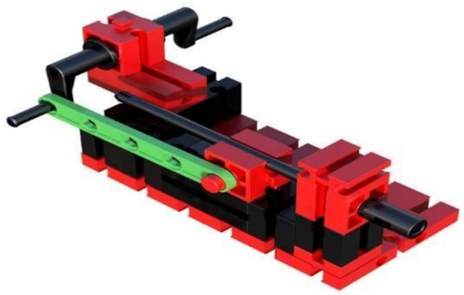
When the content analysis performed on the course plan has been evaluated in the context of the mathematical skills dimension, it has been determined that the mathematical skills that have been targeted to be developed with the use of building tasks have been modeling (75%), reasoning (57%) and visualization (39%) (Table 3). In building tasks developed with static sets, the modeling process has often been handled over the GCD-LCM topic by comparing the number of rotations of the wheels from simple machines in a system. In building tasks, it has been observed that proportional reasoning ability, which means instant change or rate of change of one quantity over another, has mostly been treated on ratio and proportion subject.

Table 3. Distribution of tasks in terms of targeted skills

Mathematical skills	Building tasks		Coding tasks	
	f	%	*f*	%
Algorithmic thinking	9	32	19	68
Modelling	21	75	8	29
Reasoning	16	57	8	29
Visualization	11	39	12	43
Arithmetic	6	21	6	21

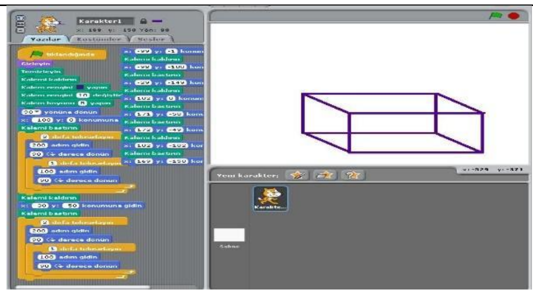
The reflections of rotational movement in visual-spatial perception such as translation, rotation and symmetry have been included in 39% of the lesson plans developed within building tasks. For example, tasks to show how the new position and shape of the largest wheel change according to the number of rotations in the smallest wheel on visual perception have been presented in the lesson plans. It was determined that tasks involving arithmetic and algorithmic skills (e.g. GCD-LCM calculation or pattern finding) have been relatively limited in the lesson plans prepared by the participants (Table 3).

In the lesson plan presented in Figure 2, a task example including modeling and visualization skills that aims to help the students discover the relationship between the rotational movement and linear motion, and the model is presented. In this lesson plan, it is seen that the real-life problems related to science are expressed with mathematical models and transferred to the lesson plans with the number of rotations in the arm, the length of the arm and the change in the bar length (Figure 2). Approximately two-thirds of the participants stated that students could develop their algorithmic thinking skills through coding tasks in their lesson plans (68%). In lesson plans that require the ability to think algorithmically, tasks such as movement, rotation, and finding a location according to the axis of symmetry to enable students to go to the positions specified on the coordinate plane by adding conditions and loops to the block-based codes are included. In some tasks that require algorithmic thinking, sub-applications that require computing or visualization skills have been placed with the "conditions" option on block-based coding, thus the content that requires more than one mathematical thinking skills has been included in them. For example, in the coding task given in Figure 2, the participant-13 targeted to develop algorithmic thinking and visualization skills. Almost half of the participants have described their coding tasks as a means of visualization that can be embodied in algebraic expressions (43%) (Table 3).



This system converts the rotary motion into linear motion.
i) Formulate the relationship between one full turn of the arm and the movement of the red piece on the black bar.
ii) Determine the position of the arm on the hoop if the bar was to be extended by two inches,

Building task



Considering the above coding made to form a rectangular prism,
i) Develop a program that finds the number of surfaces.
ii) Develop a program that finds the surface area.

Coding task

Figure 2. The building and coding task of participant-13

When the task types were compared, it was observed that while in building tasks modeling was more reflected, algorithmic thinking skills were more focused on coding tasks. It was determined that visualization skills were preferred in similar proportions and frequently in both types of tasks while less attention was paid to arithmetic skills. While more than one mathematical skill was included in 21 of the building tasks in the lesson plan, at least two mathematical skills have been referred to in 15 of the lesson plans designed according to coding tasks. In this context, it was determined that building tasks have been more frequently associated with more than one skill compared to coding tasks.

4.3. Participants' Views on the Usefulness of the Tasks

Participants have been expected to evaluate the tasks they developed in terms of usefulness in mathematics classes after their experience in interdisciplinary teaching practices and coding teaching practices. In this sense, the tasks developed by the participants have been subjected to the self-evaluation and peer-evaluation process, thus each task has been evaluated by at least two participants. Participants' views on the usability of building and coding tasks in classroom practice are presented as a percentage in the four-level (never-rarely-sometimes-always) category in Figure 3.

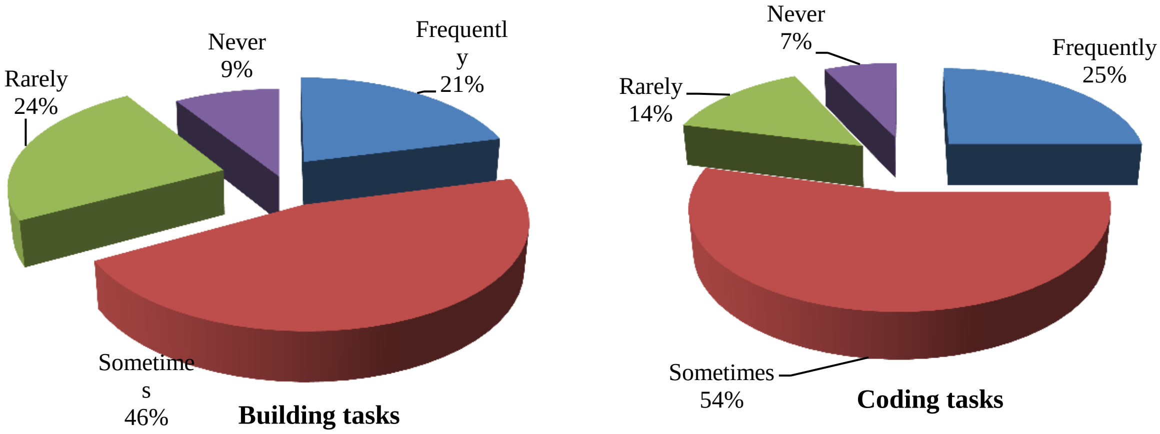


Figure 3. Participants' views on the usefulness of the tasks in the teaching process

When comparing the usefulness of the tasks in the teaching process, building tasks have been evaluated as always usable in the classroom environment by 21% of the participants, while 46% have been evaluated as sometimes. Participants who claimed they were rarely usable, or they will not use it made up one-third of all participants. When the coding tasks have been examined, one-fourth of the participants evaluated such tasks in the always usable category in classroom practice. More than half of the participants stated that they can sometimes benefit from coding tasks. When two types of tasks were compared, it was seen that coding tasks have been found more useful by the participants compared to building tasks. The number of participants indicating that they will use coding tasks always or sometimes is seven more than the number of participants who stated that they will use building tasks for the same categories. It was observed that in both building and coding tasks, a more significant part of the participants found the tasks sometimes usable and the number of participants who thought that both types of the tasks were always usable was few.

Participants were also asked to evaluate the tasks they developed in terms of their usefulness and limitations in mathematics class. Participants emphasized that especially coding tasks are useful since they offer the opportunity to learn math by gamification *(f = 16)*. Expressing that the students can solve their math problems as if they were preparing a game program, the participant-5 claimed in the interview findings that with these tasks, students can improve the quality of the time they spend at the computer on a daily routine. The most striking point made considering the limitation of coding tasks was the difficulty in finding the appropriate task for each topic *(f = 14)*. Following is a quotation from a participant that exemplifies the above argument.

> ***Participant-5****: Today's students plan even their social lives on computer. The presentation of mathematics to students with a game culture generally overlaps with their real-life practices… Trying to embed the learning outcomes within the tasks can be quite difficult. In particular, developing such tasks for each mathematical concept can adversely affect usefulness.*

The most common view for the advantage of building tasks has been the tasks offering opportunities for mathematical modeling *(f = 10)*. One of the interview sections exemplifying this advantage is presented below. Participant-2 stated that building task will contribute positively to visualization as well as modeling skills. The most notable view for the limitation of building tasks in mathematics courses which more than half of the participants agree with has been the need for material installation knowledge and the sets not being economical *(f = 15)*. In addition, the lack of mathematical skills being visible enough might have made the participants feel reluctant to use building tasks.

> ***Participants-2****: The situation in which students have the most difficulty in secondary school mathematics is the crisis they experience in the process of transitioning from real-world models to abstract mathematical models, and interdisciplinary approaches can be useful against this issue. If I evaluate the building tasks that I have encountered so far, I can say that mathematics is far behind, and the subjects are mostly related to science.*

4. DISCUSSION AND CONCLUSION

Findings obtained from the study have been discussed under two headings: the characteristic of developed tasks by participants (via curriculum integration) and participants' views on the usefulness of tasks in the teaching process (via participating of interdisciplinary mathematics teaching course). When the lesson plans developed by the participants were evaluated in terms of content domain, it was determined that the participants found building tasks more useful in numbers domain and coding tasks in geometry domain. The reason why compliance with the curriculum integration varies according to task types may be related to the participants generating tasks on limited subjects. When the lesson plans were analyzed in detail, it was found that the aim was to help students comprehend the ratio and proportion subject and achieve proportional reasoning skills within the framework of building task. This finding shows that the skills (proportional reasoning) that will help the learning process in the selected content domains (ratio and proportion) have been preferred more frequently in lesson plans. In this sense, the compatibility of the subject and the skill may have led to the building tasks to be more associated with the numbers content domain. Besides, geometry content domain was preferred frequently when developing coding tasks and algorithmic thinking skills often cited in these tasks rather than visual-spatial skills. Although geometry content domain is preferred in coding tasks, Francis and Davis (2018) found a strong relationship between coding with arithmetic and multiplication in their study. In the study, children aged 9 and 10 were asked to write codes to move the Lego robots. It was reported that the transition of children from additive to multiplicative correlations was strongly supported in this process. In this case, the computational thinking skills of students can be developed by designing tasks that support similar learning outcomes (Aydın, et.al., 2019; Grover & Pea, 2013; Taylor, Harlow, & Forret 2010). While the rationale of countries such as England, Finland and Australia that add coding to curricula is to support logical thinking and problem solving, these justifications overlap with the findings of the study (Sayın & Senemoğlu, 2016), because it was stated in the interview findings obtained from the participants that coding tasks such as writing code or creating appropriate commands could be used mostly to solve mathematical problems.

When the findings regarding the usability of building and coding tasks in classroom practice are examined, the fact that a significant number of participants found both tasks sometimes usable suggests that participants are distant from using these tasks in the course. Similar inferences were encountered in the findings of the interview. Failure of participants to find building and coding tasks useable can be explained mainly by two situations. Firstly, pre-service teachers might have considered negative factors such as the technological-pedagogical knowledge, course hours, and the infrastructure of schools for applying such tasks. The material and pedagogical knowledge of the participants can be considered as a source of influence in building resistance to the usability of such tasks in the classroom practice (Sevimli & Ünal, 2020). For this reason, the participants have more positive opinions about the integration of coding tasks into the curriculum, which require less material knowledge compared to building tasks. If mathematics discipline is less visible in tasks carried out with STEM sets and science subjects are more prominent in these tasks, then the participants may have negative beliefs related to the integration of the tasks into the curriculum. Moreover, participants find it hard to develop appropriate tasks for each learning outcomes in curriculum. As a result, the participants are more distant from building tasks, than they are from the coding tasks. However, here, pre-service teachers need to be encouraged to use mathematical modeling as a bridge to integrate STEM tasks into their courses and see and use mathematical modeling and STEM tasks as complementary partners (Blum & Ferri, 2009; Özdemir, Sevimli, Aydın, & Derin, 2018). According to English (2015), while mathematics education provides foundational content and processes that bridge the STEM disciplines, the difficulty of mathematics educators is not being aware of these contributions. Secondly, the teaching process may also have influenced participant views. Although the content prioritizing the integration of mathematics with the interdisciplinary approach was presented to the participants in the course (interdisciplinary mathematics teaching course) provided within the scope of this study, the outcomes of the course included in the particular time may have been limited. It is also expected that the participant group in which the study was conducted would be more open to innovations since they are pre-service teachers. In this context, it may be necessary to plan the mathematical infrastructure and nature of the contents carefully, considering that more experienced teachers with teaching habits will show more resistance in such practices. Undoubtedly, the predictions that researchers make between teaching experience and resistance to change are in need of confirmation, and at this point, a similar study is suggested to be carried out with in-service teachers.

The study showed attitudes of pre-service teachers while preparing their lesson plans differ with respect to their choice of the task type (building tasks vs. coding tasks). Pre-service teachers tend to use the "numbers" content domain in building tasks and "geometry" content domain in coding tasks more frequently. In addition, compared to coding tasks, pre-service mathematics teachers associated building tasks with mathematical skills more while preferring building tasks in the development of mathematical modeling skills and coding tasks in the development of algorithmic thinking skills.

Nevertheless, pre-service mathematics teachers found coding tasks more useful into curriculum integration compared to building tasks. According to the pre-service mathematics teachers, building tasks can be integrated curriculum to achieve modeling real-life problems, while the limitation of them is the need for knowledge of material installation and the high cost of the sets. In addition to this, the interview results pointed out that the advantage of coding tasks in mathematics classes is teaching with games while the limitation is the difficulty of developing task compatible with every subject for teaching.

As a result of the study, considering the limitations of the building tasks with the sets (high costs and the need for the installation knowledge), it is thought that teachers would use these tasks more in mathematics classes if the STEM sets were easily accessible and carried out with the equipment in the classroom environment. We think that pre-service or in-service training, which focuses on various subjects and mathematical skills that can be used in classroom practice, may positively affect the views of the instructors. Since this study was carried out with pre-service teachers, it is wondered what the results of a study would be with a similar research focus conducted with in-service teachers with different teaching experiences. In addition, in this study, two different teaching situations carried out using static sets and coding training were compared with each other and the combined effect of these two situations in cycles was not included. In this context, a study evaluating pre-service or in-services teachers' opinions about the effectiveness of a teaching process that will be developed using dynamic or robotic sets will contribute to the literature.

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