Educational Policy Analysis and Strategic Research, V18, N4, 2023

An Examination of Fourth-Grade Primary School Students' Intrinsic Motivation in Mathematics and Their Mathematics Achievement in Terms of Their Favorite Subject [1]

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Abstract

The aim of this study is to explore the correlation between the intrinsic motivation of fourth-grade primary school students in mathematics and their academic performance in mathematics while considering the factor of their favorite subject. The goal is to determine whether there is a difference in intrinsic motivation and achievement in terms of their favorite subject. A convergent parallel design was used in the study. The sample of the research consisted of 142 students who participated in face-to-face research in the city center and districts of Çanakkale in the 2019/2020 academic year, as well as 109 students who participated in online research in the 2020)2021 academic year. The study group was comprised of 10 students, for whom the data were collected in face-to-face sessions, and 12 students who participated in the research online. The data for this study were collected using the "Mathematics Lesson Motivation Scale" developed by Balantekin and Oksal (2014), as well as the "Mathematics Lesson Achievement Test", "Demographic Form", and "Semi-Structured Interview Form" developed by the researchers. When examining the results of the research related to intrinsic motivation, significant differences were observed in both online and face-to-face data collection, with respect to the obtained data. According to the qualitative data obtained from this study, those students with intrinsic motivation were expected to perform well in the course. However, it was observed that regardless of their academic performance, all students were motivated towards the course. As a contrasting result, it was determined that the most successful student in the school did not possess intrinsic motivation towards the course.

Keywords: Mathematics, Motivation, ARCS Model of Motivation, Self-Determination Theory, Constructivist Approach

DOI: 10.29329/epasr.2023.631.9

Submitted: 12 October 2023 **Accepted:** 14 December 2023 **Published:** 30 December 2023

[1] It is derived from the master's thesis titled "Examination of Various Variables the Correlation Between Fourth Grade Primary School Students' Mathematics Course Achievement and Motivations for Mathematics Course". (Thesis Number: 708996)

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Introduction

The theoretical framework of this research is formed at the intersection of the Constructivist Approach, Self-Determination Theory, and the ARCS Model of Motivation.

Constructivist Approach

In Turkey, the term "yapılandırmacılık" is used as the equivalent of the word "constructivism". Other terms and word groups that correspond to this approach include "oluşturmacılık", "kurmacılık", "bütünleştiricilik", "yapılandırıcı-yapısalcı öğrenme", and "oluşumcu yaklaşım" (Demirel, 2001). From an educational perspective, constructivism is a concept or framework of learning (Karadağ et al., 2008). It is based on the fundamental idea of constructing knowledge, not through teaching but through the engagement with knowledge and learning (Demirel, 2000).

Socrates, one of the early proponents of constructivism, is known for his idea that "teachers and learners should build knowledge by conversing and asking each other various questions, interpreting the knowledge hidden in their souls" (cited in Erdem and Demirel, 2002). According to Arslan (2007), the pioneers of constructivist thinking in past centuries include Giambattista Vico, Jean-Jacques Rousseau, and Immanuel Kant, while the twentieth-century thinkers who focused on the classroom and child development were Jean Piaget, John Dewey, Bruner, and Vygotsky. However, when examined in detail, many sources point to Dewey and Piaget as the true pioneers. Piaget's cognitive development theory, in particular, is seen as a foundation for the constructivist approach. According to Bayraktaoğlu (2011), this approach, based on Piaget's insights into cognitive development and knowledge construction, emphasizes the importance of focusing more on learning than teaching. According to this view, learners do not simply absorb knowledge; instead, they construct knowledge themselves. They synthesize new information with their previous knowledge to create their own understanding. Thus, the most prominent feature of this approach is the active role of the learner in the process of learning.

Mathematics

There are two different views regarding the emergence of mathematics. The first one is that mathematics is invented by humans themselves. The other view is that mathematics already exists in the universe itself, and that humans have come to realize it over time. There are quite a few natural pieces of evidence that support the latter view more than the former (Sapma, 2013). Discovery or invention, whichever it may be, is one of the most significant products of human intellectual potential. Considering that it is also present in art and our daily lives, there is a magical aspect to mathematics, and the metaphor that mathematics is the language of God often comes up (Gül, 2021, p.4452).

Motivation

The conceptual origins of motivation can be traced back to Latin. The Latin word "movere," which means to move or to set in motion, forms the basis of the modern concept of motivation (Altok, 2009, p.1). Motivation is crucial in the learning and teaching process because it provides individuals with the energy to become willing to engage in behaviors (Bozkurt and Bircan, 2015). A student who lacks sufficient motivation is not prepared for learning activities. Motivation is one of the most important sources of power that determines the direction, intensity, determination level, and speed of an individual's actions and their attainment of expected goals in educational environments (Akbaba, 2006).

Success and Motivation

Motivation, which positively influences success, is an important factor that facilitates learning. All these characteristics mentioned are sufficient to emphasize the importance of the motivation process for individuals (Demir and Budak, 2016). Variables related to motivation have been the subject of numerous studies as factors that explain differences in individuals' levels of achievement. Metallidou and Vlachou (2007) found that students who are interested in their lessons and value success in their studies were more likely to succeed (cited in Öztürk, 2016). When planning motivation strategies at the beginning of a course, efforts should be made to cultivate a positive attitude in students. To achieve this, opportunities should be provided for students to feel confident and express themselves comfortably at the start of the course (Karslı, 2015). Mathematics motivation is a criterion for how individuals embrace mathematical challenges, value their mathematical abilities, and consider the importance of performing well in mathematics (Gottfried et al., 2007, cited in Süren, 2019).

Self-Determination Theory

The initial studies on Self-Determination Theory were conducted in the 1970s by Edward Deci, with another important representative being Richard Ryan (cited in Çankaya, 2009). The purpose of Self-Determination Theory is to identify the conditions that foster the development of individuals, groups, and communities and to clearly define the factors that actively play a role in the processes of growth, integration, and well-being (Deci and Ryan, 2000, p.227). In contrast to cultural and psychodynamic approaches, the theory defines autonomy as a sense of behaving consciously, rather than as a form of self-approval. It presents an approach based on understanding the developmental process of motivation with personality. Consequently, autonomy represents an individual's initiation, continuation, and completion of actions with their own consciousness (cited in Taştan et al., 2017).

The theory acknowledges that basic psychological needs are universal (Deci and Ryan, 2000, p.232). From this perspective, mental needs that begin at birth are examined under three headings: autonomy, competence, and relatedness needs represent these three requirements (cited in Kocayörük,

2012, p.25). Meeting these needs is necessary for an individual's growth, integration, development, psychological well-being, and overall well-being (Deci and Ryan, 2000; Andersen, 2000, cited in Çankaya, 2009).

ARCS Model of Motivation

John M. Keller's ARCS model of motivation stands out as one of the most widely used models in motivation theories in educational studies. The foundations of the theory are based on Victor H. Vroom's Expectancy-Value Theory (1964) (Bixler, 2006, cited in Yıldız et al., 2019), and the theoretical structure of the ARCS motivation model was developed by Keller in 1987 as a synthesis of studies on human motivation (Varol et al., 2014). The model (Keller, 1979, 1983) attempts to answer questions such as how motivational strategies can be used in teaching with the aim of stimulating students' learning motivation and sustaining their motivation (cited in Çetin and Mahiroğlu, 2008). The ARCS model of motivation is a problem-solving approach created to design learning environments from a motivational perspective, aiming to promote and sustain motivation in an instructional environment where motivating ways are explained (Çetin, 2007), and it is also designed to create a motivational problem-solving approach for designing learning environments (Tahiroğlu, 2015) (Keller, 1983, 1984, 1987; cited in Varol et al., 2014). The ARCS Model of Motivation consists of the initial letters of the words Attention, Relevance, Confidence, and Satisfaction, and each of these four main dimensions is divided into three sub-dimensions (Keller, 2000).

Purpose of the Study

The research aims to predict the impact of the level of motivation in mathematics lessons, particularly the intrinsic motivation variable, on the results of mathematics class achievement. Some key factors that are thought to potentially influence motivation total scores and mathematics class achievement were identified and the central focal points of the subject were determined. To achieve these answers to the following questions were sought based on the data collected in both face-to-face and online settings from the fourth-grade primary school students:

1. What are the Mathematics Report Card Grade, General Report Card Grade, Total Achievement Test Score, Intrinsic and Extrinsic Motivation, and Demotivation levels of the fourth-grade primary school students who participated in the study?
2. Is there a relationship between the Mathematics Report Card Grade, General Report Card Grade, Total Achievement Test Score, Intrinsic and Extrinsic Motivation, and Demotivation scores of the students?
3. Do intrinsic motivation scores differ based on the favorite subject of the students?
4. What are the opinions of the students on intrinsic motivation for mathematics lessons based on the data collected in face-to-face and online settings?

Method

Participants

The quantitative population of the research consists of fourth-grade students who are enrolled in schools in Çanakkale city center and all districts. The quantitative sample of the research was determined using the "simple random sampling technique" from the population. Accordingly, the sample consisted of 142 students attending the fourth grade of 5 primary schools in Çanakkale city center and districts, from whom the data were collected face-to-face during the 2019/2020 academic year. Additionally, the data collected online during the 2020/2021 academic year included 109 students from 6 primary schools in Çanakkale city center and districts.

For the qualitative study group of the research, the "purposive sampling" method, which includes "extreme case sampling", was used. According to Büyüköztürk (2016), extreme case sampling is considered to provide a clearer view of variability by selecting extreme cases that are contradictory (outliers) in relation to the problem under consideration. As an example of this sampling type, if a researcher aims to explain the success and failure status of students by examining their performances in various dimensions, they may choose schools where student achievement is the highest and lowest, depending on the goal they want to achieve.

Based on the data collected face-to-face during the 2019/2020 academic year, the qualitative study group of the research consisted of 10 students who were enrolled in 5 schools located in Çanakkale city center and districts. On the other hand, based on the data collected online during the 2020/2021 academic year, the study group was determined to consist of 12 students from 6 schools.

Table 1. Frequency and Valid Percentage Distributions of Fourth-Grade Primary School Students' Favorite Subject (FS) Data Based on Data Collected in Online

	Variables	Frequency	Valid percentage
FS	Mathematics	57	52,3
	Turkish	11	10,1
	Science	23	21,1
	Social Studies	2	1,8
	English	8	7,3
	Music	1	,9
	Religion and Ethics	2	1,8
	Physical Education and Sport	5	4,6
	Total	109	100,0

Table 2. Frequency and Valid Percentage Distributions of Fourth-Grade Primary School Students' Favorite Subject (FS) Data Based on Data Collected in Face-to-Face Environment

	Variables	Frequency	Valid percentage
FS	Mathematics	58	40,8
	Turkish	12	8,5
	Science	17	12,0
	Social Studies	11	7,7
	English	8	5,6
	Music	3	2,1
	Religion and Ethics	7	4,9
	Visual Arts	6	4,2
	Physical Education and Sport	19	13,4
	Human Rights	1	,7
	Total	142	100,0

Research Model

The research adopts a convergent parallel design, which is one of the mixed methods. The purpose of this design is to collect, merge, and use qualitative and quantitative data simultaneously to understand the research problem. The fundamental idea behind this design is to balance the strengths of one type of data with the weaknesses of the other type, and to develop a more comprehensive understanding of the research results obtained from both quantitative and qualitative data (Creswell, 2012). In mixed models, the main goal is to use multiple techniques that are compatible with each other within the same paradigm. The aim is to make the data more valid and reliable and to improve the quality of the study. Models can consist of two different models of the same research method or can contain models of multiple methods (Spratt et al., 2004; cited in Balcı, 2009, p.44; cited in Kıncal, 2017).

The convergent parallel design typically assigns equal priority to both quantitative and qualitative data. It values both types of data and sees them as roughly equal sources of information. Throughout a study, both quantitative and qualitative data are collected either simultaneously or sequentially (Creswell, 2012).

Environtment and Tools

The face-to-face data for the research were collected from 4th-grade students in the selected primary schools in their own classrooms using the data collection tools, which included a personal information form, a semi-structured interview form, the Mathematics Lesson Motivation Scale, and the

Mathematics Lesson Achievement Test. The online data for the research, on the other hand, were collected through Google Forms via the internet using the same data collection tools.

Data Collection Tools

Personal Information Form

The research aimed to collect information on the ages of the participating students, their parents' educational backgrounds, the number of siblings, whether they had a dedicated study room, the amount of time allocated to studying mathematics and reading books during the day, the previous semester's mathematics report card grade, and the identification of their favorite subjects. Among the data collected through the form, only the favorite subject was examined in this study.

Semi-Structured Interview Form

In the semi-structured interview form, three open-ended questions were asked, aiming to gather information about the sub-factors of demotivation, intrinsic motivation, and extrinsic motivation. However, in this research, the focus was solely on the first question, which attempts to determine intrinsic motivation. Here are the questions:

1. Do you think the only important thing in mathematics lesson is to learn the topics? What benefits can learning this lesson provide for you?
2. Are you studying mathematics just to meet the expectations of your family or others?
3. Are you interested in mathematics lesson? If this lesson does not interest you, what is the reason for it?

Mathematics Lesson Motivation Scale

The scale developed by Balantekin and Oksal (2014) aims to determine the motivation levels of third- and fourth-grade primary school students in mathematics lessons. The scale is in a 5-point Likert style, with scoring options as follows: Strongly Agree (5), Agree (4), Neutral (3), Disagree (2), Strongly Disagree (1). There are no negative items in the scale. Therefore, the extrinsic motivation and demotivation factors consist of five items each, allowing for a minimum score of 5 and a maximum score of 25. The intrinsic motivation factor consists of four items, allowing for a minimum score of 4 and a maximum score of 20. As a result of factor analysis, the scale consists of three factors: the first factor is extrinsic motivation (Cronbach's $\alpha = 0.78$), the second factor is demotivation (Cronbach's $\alpha = 0.71$), and the third factor is intrinsic motivation (Cronbach's $\alpha = 0.61$).

Mathematics Lesson Achievement Test

The achievement test used in the research was developed by the researchers based on the fourth-grade mathematics curriculum. The purpose of the test is to assess the success of fourth-grade students

in the domain of numbers and operations. The test consists of 25 multiple-choice questions. Scoring for the test is conducted as 0 or 1. Correct answers receive 1 point, while each incorrect answer is scored as 0 points. This test covers the learning domain of numbers and operations, including natural numbers, addition with natural numbers, subtraction with natural numbers, multiplication with natural numbers, and division with natural numbers, and includes 28 learning objectives, covering the topics of the first three units. All the questions prepared are suitable for the fourth-grade mathematics textbook and the learning objectives in the fourth-grade mathematics curriculum. To prepare the achievement test, validity and reliability studies were conducted with 196 students from five different schools, and the data obtained were analyzed using TAP (Test Analysis Program). According to the final analysis results, the KR-20 reliability coefficient of the test was calculated as 0.841. Considering that a test should have a reliability of 0.80 or above, it can be concluded that the developed achievement test is reliable. Thanks to the item analysis, the standard deviation of the test, in its final form, was calculated as 5.204, and the standard error as 2.078. It was observed that there were no items of poor, weak, or moderate quality in the final version of the test, and all items in the test were found to be of good and very good quality.

Data Collection

The research was conducted with the official permission of the Çanakkale Governorship and the Çanakkale Provincial Directorate of National Education. The research also obtained ethical approval from the Çanakkale Onsekiz Mart University Social Sciences and Education Sciences Ethics Committee with document (number: 2018/58; date: 09/11/2018).

To collect data, initially, consent forms for parents were distributed in the designated schools in the districts. On another day approved by the schools, the research was conducted in the same district. During the implementation, an examination environment was created, and the application was carried out, giving equal time to all students with parental consent in the classroom. While the data collection process was ongoing, due to the COVID-19 pandemic and the interruption of face-to-face education in schools, the remaining data were collected in the following academic year, 2020/2021, in accordance with the permission granted by the provincial education authorities. This part of the data collection was conducted in an online format.

Table 3. Frequency and Valid Percentage Distributions of Fourth-Grade Primary School Students' Favorite Subject (FS) Data Collected in Online Environment

Variables	Frequency	Valid percentage
Mathematics	57	52,5
Turkish	11	10,1
Science	23	21,1
Social Studies	2	1,8

English	8	7,3
Music	1	,9
Religion and Ethics	2	1,8
Physical Education and Sport	5	4,6
Total	109	100,0

When we examine Table 3, we can see that the students' favorite subject is mathematics by a significant margin, followed by science. The least favorite subjects are music, social studies, and Religion and Ethics.

Table 4. Frequency and Valid Percentage Distributions of Fourth-Grade Primary School Students' Favorite Subject Based on Face-to-Face Gathered Data

Variables	Frequency	Valid percentage
Mathematics	58	40,8
Turkish	12	8,5
Science	17	12,0
Social Studies	11	7,7
English	8	5,6
Music	3	2,1
Religion and Ethics	7	4,9
Visual Arts	6	4,2
Physical Education and Sport	19	13,4
Human Rights	1	,7
Total	142	100,0

When we examine Table 4, in the face-to-face gathered data, mathematics comes first in the students' favorite subjects, followed by physical education and sport and science. In this group, the subject with the smallest share is human rights course, which was only chosen by one student.

Data Analysis

In the analysis of the quantitative data of the research, SPSS 26 software package was used. Before the statistical procedures of the research, the Kolmogorov-Smirnov test (Mertler and Reinhart, 2017) was conducted to determine the normality distribution, which is a prerequisite for parametric tests. Based on the Kolmogorov-Smirnov values in Table 5 (collected in online environment) and Table 6 (collected in face-to-face environment), it was determined that the distribution was not normal. Therefore, non-parametric tests were used in the research. These tests are Mann-Whitney U, Kruskal-Wallis, and Spearman Rank-Order Correlation, respectively. Additionally, the arithmetic mean and standard deviation values of both online and face-to-face data types were examined. For the qualitative data of the research, content analysis was utilized. The primary aim of content analysis is to access concepts and relationships that can make sense of the obtained data. For this purpose, it is necessary to

conceptualize the data initially, and in the end, organize the data logically according to the concepts formed, and determine the themes that explain the data accordingly (Yıldırım and Şimşek, 2018, p. 242).

Table 5. The Kolmogorov-Smirnov Values for the Intrinsic Motivation of Fourth-Grade Primary School Students Collected in Online Environment

	Kolmogorov-Smirnov		
	Statistics	sd	p
Intrinsic Motivation	,131	109	,000

When examining Table 5 to determine whether the data followed a normal distribution, it is evident that the intrinsic motivation sub-factor showed a significant difference at the $p < .001$ level.

Table 6. The Kolmogorov-Smirnov Values for the Intrinsic Motivation of Fourth-Grade Primary School Students' Intrinsic Motivation Based on Face-To-Face Gathered Data

	Kolmogorov-Smirnov		
	Statistics	sd	p
Intrinsic Motivation	,112	142	,000

According to Table 6, there is a significant difference at the $p<.001$ level in the Intrinsic Motivation sub-factor. Non-parametric test types were used in the research based on the results of the normality of the distribution, which was performed to determine the type of analysis to be used for both online and face-to-face gathered data.

Findings

The findings of the research were presented in two main sections, aligning with the objectives of the study: quantitative sample findings and qualitative findings from the study group. In the qualitative study group of the research, the participants were assigned code names instead of their real names.

Findings of Quantitative Sampling

Subproblem 1: Findings related to Mathematics Report Card Grade (MRCG), General Report Card Grade (GRCG), Total Achievement Test Score (TATS), Intrinsic (IM) and Extrinsic Motivation (EM), and Demotivation (DM) levels in the data collected in the online environment.

Table 7. Mean and Standard Deviation Values of MRCG, GRCG, TATS Total Scores, and IM, EM and DM sub-factors Based on Data Collected in Online Environment

	MRCG	GRCG	TATS	IM	EM	DM
$\bar{x}$	91,781	93,475	18,055	3,254	1,888	1,655
S	10,334	7,216	,989	1,186	,712	,618

When Table 7 is examined, it is possible to evaluate the average and standard deviation results of the students participating in the online environment research. Accordingly, it can be concluded that the students are quite successful in their schools by looking at their mathematics and general report card grades. In addition, considering the mean value of 18.055 for the 25-question mathematics achievement test, it can be inferred that the students achieved a success rate of 72.22% on the test.

Subproblem 2: Results related to the levels of MRCG, GRCG, TATS, IM, EM, and DM and scores Based on Face-to-Face Gathered Data

Table 8. Mean and Standard Deviation Values of MRCG, GRCG, TATS Total Scores, and IM, EM and DM sub-factors Based on Face-to-Face Gathered Data

	MRCG	GRCG	TATS	IM	EM	DM
$\bar{x}$	85.126	87.618	15.591	.784	.513	.457
S	13.026	10.169	1.134	.176	.227	.203

When we examine Table 8, it can be concluded that the students who participated in the study in the face-to-face environment were successful in their mathematics and general report card grades. When we look at the average of the correctly answered questions in the developed achievement test, we see a value of 15.5915 out of 25 questions. It can be inferred that more than half of the questions were answered correctly, and when we calculate the success rate as a percentage, we get a value of 62.366. Comparing the data collected in the face-to-face environment with the online data, it is noticeable that the students who participated in the study face-to-face have lower MRCG and general report card grades, as well as lower MDBT results compared to other students.

Subproblem 3: Results regarding the relationship between the total scores of MRCG, GRCG, TATS, IM, EM, and DM in the data collected in the online environment.

Table 9. The Spearman Rank Correlation Results for Continuous Variables in Online Data

Variable	1	2	3	4	5	6
1. Mathematics Report Card Grade	1,000	,875**	,244*	-,266**	-,206*	,296**
2. General Report Card Grade	,875**	1,000	,158	-,273**	-,067	,319**
3.Intrinsic Motivation	,244*	,158	1,000	-,130	-,403**	,437**
4. Extrinsic Motivation	-,266**	-,273**	-,130	1,000	,585**	-,025
5. Demotivation	-,206*	-,067	-,403**	,585**	1,000	-,095
6. Total Achievement Test Score	,296**	,319**	,437**	-,025	-,095	1,000

According to the analysis results in Table 9, there was a significant relationship between the mathematics report card grade and the general report card grade of the fourth-grade primary school students ($r=0.875$, $p<0.01$); a positive relationship between the mathematics report card grade and intrinsic motivation ($r=0.244$, $p<0.05$); a negative relationship between the mathematics report card grade and extrinsic motivation ($r=-0.266$, $p<0.01$); a negative relationship between the mathematics report card grade and demotivation ($r=-0.206$, $p<0.05$); and a significant relationship between the

mathematics report card grade and the total score of the mathematics achievement test (r=0.296, p<0.01). Moreover, there was a significant relationship between the general report card grade and the mathematics report card grade of the participating students (r=0.875, p<0.01); a negative relationship with extrinsic motivation (r=-0.273, p<0.01); and a significant relationship with the total score of the mathematics achievement test (r=0.319, p<0.01).

There was a significant relationship between intrinsic motivation and the mathematics report card grade (r=0.244, p<0.05), but no significant relationship was found between the general report card grade (GRCG) and intrinsic motivation. There was a negative significant relationship between intrinsic motivation (IM) and demotivation (DM) (r=-0.403, p<0.01), as well as between the total score of the mathematics achievement test and intrinsic motivation (r=0.437, p<0.01). The demotivation (MS) variable had a negative significant relationship with the mathematics report card grade (r=-0.266, p<0.01) and the general report card grade (r=-0.273, p<0.01). However, there was no significant relationship between intrinsic motivation (IM) and the total score of the mathematics achievement test. There was a strong negative significant relationship between the demotivation (MS) variable and intrinsic motivation (IM) (r=-0.585, p<0.01). Demotivation also had a negative significant relationship with the mathematics report card grade (r=-0.206, p<0.05) and intrinsic motivation (r=-0.403, p<0.01). Regarding the total score obtained from the achievement test, there was a significant positive relationship with the mathematics report card grade (r=0.296, p<0.01), the general report card grade (r=0.319, p<0.01), and intrinsic motivation (r=0.437, p<0.01). However, there was no significant relationship between the achievement test score and extrinsic motivation (EM) or demotivation (DM).

Subproblem 4: Results of the Relationship Between Mathematics Report Card Grade, General Report Card Grade, Total Achievement Test Score, Intrinsic Motivation, Extrinsic Motivation, and Demotivation Total Scores in Face-to-Face Data Collection

Table 10. The Spearman Rank Correlation Results for Continuous Variables in Face-to-Face Data Collection

Variable	1	2	3	4	5	6
1. Mathematics Report Card Grade	1,000	,832**	,168*	-,342**	-,342*	,499**
2. General Report Card Grade	,832**	1,000	,123	-,304**	-,403**	,535**
3.Intrinsic Motivation	,168*	,123	1,000	-,319**	-,433**	,162
4. Extrinsic Motivation	-,342**	-,304**	-,319**	1,000	,673**	-,488**
5. Demotivation	-,342**	-,403**	-,433**	,673**	1,000	-,465**
6. Total Achievement Test Score	,499**	,535**	,162	-,488**	-,465**	1,000

According to Table 10, in the face-to-face data collection, significant negative correlations were found between the students' MRCG and GRCG (r=0.832, p<0.01), MRCG and IM (r=0.168, p<0.05), MRCG and total scores from MDBT (r=0.499, p<0.01); as well as significant negative correlations between MRCG and EM (r=-0.342, p<0.01), and MRCG and DM (r=-0.342, p<0.01). There were

significant positive correlations between GRCG and MRCG (r=0.832, p<0.01), GRCG and total scores from TATS (r=0.535, p<0.01), and significant negative correlations between GRCG and EM (r=-0.304, p<0.01), and GRCG and MS (r=-0.403, p<0.01). No significant relationship was found between IM and GRCG, while there were significant negative correlations between IM and MRCG (r=0.168, p<0.05), IM and EM (r=-0.319, p<0.01), and IM and DM (r=-0.433, p<0.01). There were no significant relationships between GRCG and total scores from TATS.

There was a significant negative correlation between the EM sub-factor and MS (r=0.673, p<0.01), as well as a significant negative correlation between EM and MRCG (r=-0.342, p<0.01), EM and GRCG (r=-0.304, p<0.01), EM and IM (r=-0.319, p<0.01), and EM and total scores from TATS (r=-0.488, p<0.01). There was a significant negative correlation between DM and EM (r=0.673, p<0.01), DM and MRCG (r=-0.342, p<0.01), DM and GRCG (r=-0.403, p<0.01), DM and IM (r=-0.433, p<0.01), and DM and total scores from TATS (r=-0.465, p<0.01). However, there was no significant relationship between the DM sub-factor and the other variables. When looking at the total scores from TATS, there were significant negative correlations between TATS and MRCG (r=0.499, p<0.01), TATS and GRCG (r=0.535, p<0.01), TATS and EM (r=-0.488, p<0.01), and TATS and DM (r=-0.465, p<0.01). There was no significant relationship between IM and total scores from TATS.

Subproblem 5: Results regarding whether there was a difference in intrinsic motivation scores based on favorite subject in online-collected data

Table 11. Kruskal-Wallis Analysis Results for IM Based on Favorite Subject in Online-Collected Data

Variable	Favorite Subject	N	Rank mean	sd	χ2	p	significant difference
IM	Mathematics	57	71,02	7	38,408	,000	Numerical Subjects and Foreign Language
	Turkish	11	32,73				
	Science	23	34,24				
	Social Studies	2	22,75				
	English	8	57,06				
	Music	1	74,00				
	Religion and Ethics	2	6,50				
	Physical Education and Sport	5	42,10				
	Total	109					

In Table 11, significant differentiation was determined in favor of both numerical subjects and foreign language courses in IM based on favorite subject [$\chi 2$(sd=7, n=109) = 38.408, p<.05]. To determine in favor of which subject the significant difference existed, a Mann Whitney U test analysis was conducted again. For the analysis to be conducted, the subjects were categorized. The categorization of the subjects was based on the exams administered by the Student Selection and Placement Center (ÖSYM). Accordingly, mathematics-science courses were categorized as numerical

subjects, Turkish-social studies-human rights, and Religion and Ethics courses as verbal subjects, English as a foreign language, and music-art and physical education courses as talent subjects.

Subproblem 6: Results regarding whether there was a differentiation in IM scores based on favorite subject in face-to-face gathered data

Table 12. Kruskal-Wallis Analysis Results for IM Based on Favorite Subject in Face-to-Face Gathered Data

Favorite Subject	N	Rank mean	Sd	$\chi 2$	p	significant difference
Mathematics	58	84,31				
Turkish	12	68,46				
Science	17	56,38				
Social Studies	11	63,73				Numerical Subjects and Talent Aeras
English	8	72,50				
Music	3	26,17	9	15,340	,082	
Religion and Ethics	7	56,93				
Visual Arts	6	86,00				
Physical Education and Sport	19	60,82				
Human Rights	1	53,50				
Total	142					

When Table 12 is examined, unlike the data collected in the online environment, there was no significant difference in IM (Intrinsic Motivation) based on the favorite subject in the face-to-face environment [$\chi 2(df=9, n=142) = 15.340, p > .05$].

Findings of Qualitative Sampling

Subproblem 7: In the data collected online, results regarding the students' opinions on IM for Mathematics

In the research, the students who participated in the research both online and face-to-face were asked the following questions in the semi-structured interview form with the aim of determining their intrinsic motivation in the Mathematics class: "Do you think the only important thing in mathematics lesson is to learn the topics? What benefits can learning this lesson provide for you?" The responses of the students to these questions and the themes identified are as follows:

Table 13. Themes Related to the Opinions of the Students who Participated in the Research Online on Intrinsic Motivation for Mathematics Lessons

	Themes	Participants	f
	Those who believe it is necessary in every aspect of life and will bring success	K1O1, K4O2, K5O3, K7O4, K9O5	5
	Those who believe it is necessary for intellectual skills such as calculation, formula generation, and analysis	K2O1, K6O3, K10O5, K11O6	4
	Those who believe it is necessary to answer the teacher's questions	K8O4	1
	hose who believe it is necessary for their future lives	K3O2, K12O6	2
Total	4	12	12

In order to enhance the internal validity of the research, the responses of the participating students to the questions are presented below without comments. From those students who believe that mathematics is necessary in almost every aspect of our lives and that the knowledge/skills acquired in this course will bring success, K1O1 defends the view, "I think mathematics is everything. It is very important for our lives". On the other hand, K4O2 comments, "No, many things in our lives are mathematics". Emphasizing success, student K5O3 states, "It means success throughout my life", while student K7O4 suggests that life encompasses mathematics as a whole, saying, "No, our life is mathematics". Lastly, student K9O5 expresses the opinion that learning will be beneficial because mathematics is necessary in every aspect of life, stating, "I think it will be useful because it is necessary in every area of life".

From the students who believe that the mathematics lesson is necessary for mental skills such as calculation, formula generation, and analysis, K2O1 states, "It makes calculation easier". While student K6O3 expresses their view with the statement, "It enhances my analytical abilities". It is observed that student K10O5 associates mathematics with mental development, stating, "It is beneficial for my mental development". Student K11O6, on the other hand, gives the response, "It's not just about learning topics. It's also necessary for finding ease in complex subjects and generating formulas", emphasizing the importance of mathematics for handling complex concepts and formula creation.

Student K8O4 expresses their view as, "I can answer when the teacher asks questions". Among the students who believe that learning the lesson is necessary for their future lives, K3O2 states, "It provides ease in my future life, exams, and daily life", while student K12O6 responds, "It will be very useful in the future".

According to Table 13, when creating codes for the data collected online, attention was paid to the schools where the students were enrolled and their academic performance. Since only six schools from two districts participated in the research, school numbers were used to create codes instead of district abbreviations.

The "K" letters numbered with odd numbers represent the most successful students, while those numbered with even numbers represent the least successful students in the same school. In this context, the letter "K" signifies "Participant", and the numbers next to it indicate which participant they are. The codes like O1, O2 indicate which school number it is, representing the "School" information. For example, the code K12O6 tells us that the 12th participant studied at School 6 in Çan district and was one of the least successful students participating in the research.

Subproblem 8: Results regarding students' views on intrinsic motivation for mathematics in face-to-face gathered data

Table 14. Themes Related to the Opinions of the Students who Participated in the Research Online on Intrinsic Motivation for Mathematics Lessons *Themes Related to Students' Views on Intrinsic Motivation for Mathematics Among Face-to-Face Participants*

	Themes	Participants	f
	Those who believe it is necessary in every aspect of life and throughout life.	K2BG2, K7EC1, K9GÇ1	3
	Those who think it will make life easier and find the lesson enjoyable, informative, and interesting.	K1BG1, K6BY2	2
	Those who believe it is only necessary at certain times in life.	K5BY1	1
	Those who think it is beneficial for mental activities.	K3BZ1, K10GÇ2	2
	Those who consider it necessary for topics related to the market, money, and work life.	K4BZ2, K8EC2	2
Total	5	10	10

From those who believe it is necessary in every aspect of life and throughout life, student K2BG2 replied, "I don't think it's just about learning the subjects. I love this lesson because I will use it in every aspect of my life and because it interests me". The student with code K7EC1 responded, "No, I don't think so. I love mathematics because it's always necessary". The student with code K9GÇ1 stated, "Yes, these are the knowledge I will use in the future. I think I will use it throughout my life".

One of the students who believes that learning this subject can make life easier and that the lesson is beautiful, instructive, and interesting, K1BG1, commented, "Learning this lesson can make my life easier. So, learning this lesson is beautiful". The other student, K6BY2, stated, "Mathematics is an instructive and beautiful lesson".

The student with code K5BY1 believes that in mathematics, it is important to only learn the topics and that mathematics may only be necessary at certain times in life, saying, "Yes, I think it's about learning the topics. It may be necessary at certain times in my life".

Approaching the subject in terms of mental activities, the student with code K3BZ1 commented, "No. It helps my mind to expand and makes me think more". The student with code K10GÇ2 stated, "It improves me, and I'm doing brain exercises".

K4BZ2, who approaches mathematics from an economic perspective, stated, "Yes, in terms of money matters in markets". K8EC2 also mentioned, "It sometimes helps me at work".

In the face-to-face gathered data, as in the online data, school numbers were replaced with abbreviations of district names while creating codes since one school from each of the five different districts and two participants from each school were included in the research. Similarly, odd-numbered "K" letters represent the most successful students, while those with even numbers represent the least successful students in the same school. The abbreviations that follow participant numbers like K1, K2 belong to district names. For example, the code K3BZ1 indicates that the third student included in the research group is from Bozcaada district and is the most successful student from the only school in that district that participated in the research.

Discussion, Conclusion and Recommendations

The views of the fourth-grade primary school students included in the research regarding their intrinsic motivation for mathematics were determined based on their favorite subject. Additionally, their intrinsic motivation for mathematics was identified through qualitative questions.

Conclusion

When examining the values related to intrinsic motivation, significant differences were observed both in the online and face-to-face data. According to the results obtained from the qualitative data of this research, the students with intrinsic motivation were expected to be successful. However, a student represented by the code K8O4, despite being the most successful student in their school, did not exhibit intrinsic motivation for the subject when participating in the online environment. Apart from this student, all other students, regardless of their academic performance, demonstrated intrinsic motivation towards the subject. Similarly, in the face-to-face data collected in Bayramiç district, the student represented by the code K5BY1, who achieved the highest success, did not also have intrinsic motivation for the subject.

Discussion

When examining studies focused on the relationship between achievement and motivation, many research works showed a significant relationship between mathematics achievement and motivation. Examples include studies by Kılıç (2011), Budak and Demir (2016), Bolat (2007), and Akyurt (2019). In the online data, there was a significant difference observed between mathematics achievement test and intrinsic motivation. The findings from this research can be stated to align with previous studies. When considering studies that attempt to determine the relationship between motivation and achievement based solely on mathematics report card grades, in the online data, a significant relationship was observed between the mathematics report card grades of the participating students and their intrinsic motivation. In the face-to-face data, a significant relationship was found between intrinsic

motivation and the mathematics report card grades. According to the results of this research, the findings are in line with previous studies in the relevant literature.

Böyüksolak (2016), in their research on Self-Determination Theory and PISA, found significant differences in all relationships between types of mathematics motivation and basic psychological needs, except for the relationship between school belongingness and intrinsic mathematics motivation. According to the researcher, all results except the relationship between school belongingness and intrinsic mathematics motivation are consistent with Self-Determination Theory. Budak (2016), on the other hand, identified significant relationships between self-regulation strategies, motivation, and academic achievement, indicating that the variables predicting academic success are self-regulation and motivation.

Akyurt (2019) found a positive and significant relationship between motivation and achievement. According to the researcher, as the level of motivation increases, the students' interest in the subject also increases, ultimately leading to improved academic success. Kaya (2019) identified significant relationships between all motivation-related variables and mathematics achievement. Kesici and Aşılıoğlu (2017) found that mathematics motivation significantly predicted mathematics achievement. According to the researchers, this result is supported by studies aimed at determining the explanatory power of motivation on mathematics achievement. Similarly, Kesici (2018) determined that mathematics motivation explained 19.5% of mathematics achievement.

Süren (2019) found that students' motivation for mathematics significantly predicted their success in this subject. According to the results obtained in this research, it is believed that students' motivation for mathematics affects their achievement in the subject. Üredi and Üredi (2005) similarly found in their research that self-regulation strategies and motivational beliefs significantly predicted mathematics achievement. Yıldırım (2011) evaluated motivation with its sub-dimensions and reached some parallel results with the research conducted by Üredi and Üredi in 2005. According to the researchers, the impact of intrinsic motivation on mathematics achievement was found to be very weak.

Recommendations

1. The relationship between the level of motivation for mathematics and the academic performance in mathematics can be investigated in different sample groups.
2. The reasons for students' lack of motivation and the underlying variables leading to their academic failures can be researched not only for this course but also for all other courses.
3. Considering students who have intrinsic motivation but cannot succeed in mathematics, as well as students who do not have intrinsic motivation but achieve the highest success in their school in mathematics, research on IM can be expanded.

Policy Implications

The data for this research were collected both online and in face-to-face settings. The rationale for this approach was the necessity for the ongoing research to progress amid the challenges imposed by the pandemic, which had a significant impact globally. This unfortunate situation potentially spurred innovative solutions for the research. In previous periods, particularly when gathering data from elementary school students, studies were typically conducted face-to-face. In our research, the data were collected by reaching numerous students through online platforms. During the research, it became apparent to the researchers that engagement rates online were lower than in face-to-face settings. Several factors may have contributed to this, including limited internet access and insufficient technological proficiency. An example illustrating the importance of disseminating the use of web tools could be presented as a significant contribution to educational policies in research. Another potential contribution is offering insights to those developing educational policies to address the underlying structural problems that require attention. Furthermore, the observed low success rate in mathematics courses may stem from the insufficiency of changes implemented over the years. Considering this, the process of teaching mathematics, including the adoption of innovative teaching methods by educators and the integration of interactive content in courses, may necessitate revisions to the content of mathematics courses. In conclusion, another aspect of the research focuses on the relationship between motivation and success, emphasizing that interaction based on motivation plays a pivotal role. By dedicating more effort to researching and developing motivation-building activities, the study aims to contribute to the significance of motivation in educational policies.

Conflict of Interest

No potential conflict of interest was declared by the authors.

Funding Details

This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

Ethical Statement

The necessary permission for the study was obtained through the decision of the Research and Publication Ethics Committee of the School of Graduate Studies at Çanakkale Onsekiz Mart University (date: 08.12.2020; number: E-84026528-050.01.04-2000184972). The study's first author, Merve ORTA, generated it from her master's thesis.

Credit Author Statement

Author 1: Conceptualization, data curation, formal analysis, investigation, methodology, project administration, sources, software, visualization, writing-original draft preparation, writing-review and editing.

Author 2: Conceptualization, methodology, software, writing-review and editing.

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