

THE EFFECT OF MATHEMATICS INSTRUCTION BASED ON FLOW
THEORY PRINCIPLES ENHANCED WITH REALISTIC MATHEMATICS
EDUCATION ON STUDENTS' ACHIEVEMENT, RETENTION, MOTIVATION
AND FLOW STATE

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ABSTRACT

THE EFFECT OF MATHEMATICS INSTRUCTION BASED ON FLOW THEORY PRINCIPLES ENHANCED WITH REALISTIC MATHEMATICS EDUCATION ON STUDENTS' ACHIEVEMENT, RETENTION, MOTIVATION AND FLOW STATE

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The purpose of this study was to investigate the effect of mathematics instruction designed based on Flow Theory and RME on students' achievement, retention, flow state and motivation. The study was conducted in 2017-2018 spring semester for 11 weeks at a state school in İzmir. In this study, quasi-experimental research design was used. After the groups were determined to be equivalent in the pretests, they were randomly assigned as experimental and control. The experimental group consisted of 37 students, while the control group consisted of 36 students. Additionally, qualitative data were collected to support the quantitative data. The data were collected through Mathematics Test, Flow State Scale, Mathematics Motivation Scale, observations, students' diaries and interviews. The quantitative data were analyzed through descriptive statistics, *t*-tests, mixed ANOVA; determining alpha-level as .05. The qualitative data were analyzed through thematic analysis. The results indicated a significant difference between the mathematics retention scores of experimental and

control groups, in favor of experimental group. There is also significant difference between posttest flow subdimension scores of experimental and control groups, in favor of experimental group. Additionally, significant difference was found between pretest and posttest flow subdimension, and between pretest and posttest boredom subdimension of experimental group, in favor of posttests. The results indicated that the mathematics motivation scores taken from posttest compared to pretest by the experimental group were significantly higher than the scores of the control group. The opinions of experimental group students about the instruction were investigated and results were discussed with relevant literature.

Keywords: Flow Theory, Realistic Mathematics Education, Achievement and Retention, Flow State in Mathematics, Mathematics Motivation

ÖZ

AKIŞ KURAMI İLKELERİNE DAYALI GERÇEKÇİ MATEMATİK EĞİTİMİ İLE ZENGİNLEŞTİRİLMİŞ MATEMATİK ÖĞRETİMİNİN ÖĞRENCİLERİN BAŞARI, KALICILIK, MOTİVASYON VE AKIŞ DURUMUNA ETKİSİ

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Bu çalışmanın amacı, Akış Kuramı ve GME'ye göre tasarlanan matematik öğretiminin, öğrencilerin başarı, kalıcılık, akış durumu ve motivasyonları üzerindeki etkisini incelemektir. Çalışma, 2017-2018 bahar yarıyılında, İzmir'de bulunan bir devlet okulunda 11 hafta süresince yürütülmüştür. Çalışmada, yarı deneysel ön-test son-test kontrol gruplu araştırma deseni kullanılmıştır. Gruplar, öntestler sonucunda denk oldukları belirlenmelerinin ardından, rastgele bir şekilde deney ve kontrol grubu olarak atanmıştır. Deney grubunda 37, kontrol grubunda 36 öğrenci yer almaktadır. Ayrıca, çalışmada nicel verilerin desteklenmesi amacıyla nitel veriler toplanmıştır. Veriler Matematik Testi, Akış Durumu Ölçeği, Matematik Motivasyon Ölçeği, gözlemler, öğrenci günlükleri ve görüşmeler kullanılarak toplanmıştır. Elde edilen nicel veriler, alpha düzeyi .05 olarak belirlenerek, betimleyici istatistikler, *t*-testleri ve karma ANOVA kullanılarak analiz edilmiştir. Nitel veriler ise tematik analiz kullanılarak analiz edilmiştir. Elde edilen bulgulara göre, deney ve kontrol gruplarının

matematik kalıcılık puanları arasında deney grubu lehine anlamlı bir fark olduđu belirlenmiştir. Deney ve kontrol gruplarının sontest akış alt-boyutu puanları arasında deney grubu lehine anlamlı bir fark vardır. Ayrıca, deney grubunun öntest ve sontest akış alt-boyutu puanları arasında, ve öntest ve sontest sıkılma alt-boyutu puanları arasında, sontestler lehine anlamlı farklar olduđu belirlenmiştir. Deney ve kontrol gruplarının sontest matematik motivasyonu puanları arasında, deney grubu lehine anlamlı fark olduđu belirlenmiştir. Deney grubu öğrencilerinin aldıkları öğretimle ilgili görüşleri detaylı olarak incelenmiş ve bulgular ilgili alanyazın doğrultusunda tartışılmıştır.

Anahtar Kelimeler: Akış Kuramı, Gerçekçi Matematik Eğitimi, Başarı ve Kalıcılık, Matematikte Akış Durumu, Matematik Motivasyonu

To my daughter, İpek Ece

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LIST OF ABBREVIATIONS

ASD	Anxiety Subdimension
BSD	Boredom Subdimension
CESE	Central Examination for Secondary Education
ESM	Experience Sampling Method
FSD	Flow Subdimension
FSS	Flow State Scale
MMS	Mathematics Motivation Scale
MoNE	Ministry of National Education
MT	Mathematics Test
OECD	Organization for Economic Cooperation and Development
PISA	Program for International Student Assessment
RME	Realistic Mathematics Education
TIMSS	Trends in International Mathematics and Science Study

CHAPTER 1

INTRODUCTION

In this chapter, the theoretical background, the purpose and significance of the study, and the definitions of some important terms were discussed.

1.1 Background of the Study

Mathematics has become one of the disciplines used almost in every aspect of life and in other disciplines as well. Mathematics has always been perceived as one of the most important tools for many important skills such as problem solving, making predictions, analyzing various experiences in daily life, and thinking systematically, especially in developed countries of contemporary world (Kaygusuz, 2011). Mathematics is not only a logical thinking system and communication tool, but also a field of knowledge that allows us to explain the relationships between entities. Therefore, the importance of mathematics gradually increases, in relation with the changing needs of societies day by day (Aksu, 1991). Since mathematics skills are indispensable for many professions, they can be considered as a predictive factor in students' academic and professional lives (Lee, 2009). In fact, it is asserted that the development level of a field or science is highly related with the level of attainment using mathematics in that field or science (Yıldırım, 2000). People who have better ability in comprehending and using mathematics efficiently are likely to have better options in shaping their future (Ministry of National Education [MoNE], 2007). Since mathematics is highly regarded at schools, students who are confident and competent in this subject are considered to have some sort of more intellectual abilities (Grootenboer & Marshman, 2016). As a result, mathematics is recognized as the strongest tool for regulating and

organizing the world, and societies persistently put emphasis on its teaching and learning processes (Sıvacı, 2003).

However, mathematics is one of the subjects in which students at various grade levels have the least achievement (Üredi & Üredi, 2005) and low positive affective attributes (TEDMEM, 2021; Turner & Meyer, 2009). Several studies investigated the underlying causes of math failure to shed a light on this issue (Grootenboer & Marshman, 2016). Some of these studies have revealed that emotional and motivational factors might play a leading and determining role in achievement. It is stated that the students' affective characteristics such as liking the lesson, valuing it and self-confidence are the lowest in mathematics (TEDMEM, 2021), while these affective characteristics have positive correlations with academic achievement (MoNE, 2017). In addition, some research has also proved that affective characteristics such as academic motivation and enjoyment of school learning significantly decreases across childhood through adolescence, while the motivation towards mathematics reveals the most rigid decline compared with other subject areas (Daniels, 2010; TEDMEM, 2021; Van Slooten, 2013). Moreover, individuals' positive attitudes and dignification towards mathematics diminish especially in elementary school and high school years (Wigfield, Byrnes, & Eccles, 2006). Therefore, it could be very essential to benefit from different approaches that will enable students to love and enjoy mathematics by reducing these negative feelings and thoughts, make them have fun while doing mathematics, and also help them to learn mathematics more effectively. At this point, the Flow Theory put forward by Csikszentmihalyi (1975a) argues that it is possible to ensure that individuals reach the optimal state of mind, participate in the activity with great attention and concentration, and enjoy doing the activity.

On the other hand, the purpose of teaching mathematics is to allow learners to cope with issues which they may encounter in their daily activities (Korkmaz, 2004). However, learners cannot adequately adopt mathematics to daily life due to its structure consisting of abstract concepts (Adıgüzel, 2013; Albayrak, 2000; Umay, 1996). Understanding mathematical concepts is difficult because concretizing abstract thinking may facilitate mathematics teaching, but it may lead to divergence from math (Umay, 1996). As a result of this dilemma, there are important problems encountered

in understanding mathematics. In other words, the view widely held by many people that “mathematics is one of the hardest disciplines both to teach and to learn” has always been in place (Aksu, 1997, p.375) and the view that mathematics is inaccessible by many people across many societies is a belief reinforced by the popular media (Grootenboer & Marshman, 2016). Therefore, RME is an approach that supports meaningful learning by offering interesting activities to students, enabling students to create concepts according to the models they have created based on their daily life problems (Heuvel-Panhuizen, 2003; Treffers, 1991).

When we look at the national and international situation of Turkish students in mathematics, it is seen that the mathematics achievement is well below the expectations. For example, MoNE (2018) put the new examination system named as *Central Examination for Secondary Education (CESE)* into practice for the first time in 2018. It is stated that approximately 80-90% of the eighth-grade students have participated in CESE. Table 1.1 shows the correct answer rates for the subtests in CESE by years. Accordingly, the mathematics test is the test in which students showed the lowest achievement and have the most difficulty in consecutive years (MoNE, 2018; 2019a; 2020a; 2021).

Table 1.1

Mean Difficulty Index Results of Subtests in CESE by Years

	2018	2019	2020	2021
Sub-tests	p_j	p_j	p_j	p_j
Mathematics	0.24	0.25	0.26	0.21
Science	0.44	0.50	0.51	0.40
Turkish	0.62	0.59	0.50	0.47
History	0.73	0.69	0.50	0.52
Religion and Morals	0.84	0.65	0.47	0.64
Foreign Language	0.50	0.46	0.35	0.49

CESE-2018 results indicated that the correct answer rate was the lowest for mathematics subtest. Moreover, the rate of unanswered questions (left blank) in the mathematics (43%) was higher than that of other tests (Turkish, History, Religion and morals, Foreign Language, and Science). As a result, MoNE (2018) decided to extend the time allocated for the tests in quantitative section (mathematics and science subtests) from 60 minutes to 80 minutes in the next CESE. Even if extending the time allocated for quantitative tests slightly decreased the rate of unanswered questions (left blank) in the math subtest, the results did not change in the following years.

The poor performance of Turkish students in mathematics is also noticeable in international assessments. The rankings of Turkey in terms of mathematics literacy in the exams applied around the worldwide such as *Program for International Student Assessment* [PISA] and *Trends in International Mathematics and Science Study* [TIMSS] have been below expectations. Turkish pupils scored below the averages and ranked at the bottom of participating countries (MoNE, 2003; 2011; 2014a; 2016; OECD, 2003; 2006; 2009; 2012; 2015; 2018). Table 1.2 shows the scores and rankings of Turkey in PISA exams by years.

Table 1.2

Turkey's Mathematics Literacy Scores in PISA by Years

	2003	2006	2009	2012	2015	2018
OECD Mean	500	498	496	494	490	489
General Mean	489	484	465	470	461	459
Turkey's Mean	423	424	445	448	420	454
Ranking	28	43	41	44	50	42
# of countries	40	57	65	65	72	79

Turkish students took PISA exam firstly in 2003. In that year, Turkey got a mean score of 423, and ranked 28th out of 40 countries in terms of mathematics literacy (MoNE, 2005; MoNE, 2010b). Similarly, in PISA-2006 exam, Turkey had a mean score of 424,

and ranked 43rd in mathematics literacy among 57 countries, while it ranked 29th among 30 OECD countries (MoNE, 2010a). Examining the PISA-2009 exam, Turkey has increased its mathematics literacy score about 20 points compared to previous assessments and got a mean score of 445. Even so, Turkey ranked 41st among 65 participating countries, while it ranked 32nd among 33 OECD countries in PISA-2009 (MoNE, 2010b). PISA-2012 results revealed that Turkey got a mean score of 448 and ranked 44th in mathematics literacy among 65 participating countries, while it ranked 32nd among 34 OECD countries (MoNE, 2015a; OECD, 2014). However, in PISA-2015, Turkey got a mean score of 420, and ranked 50th in mathematics literacy among 72 participating countries (MoNE, 2016). These scores and rankings were below the scores received in PISA-2003 results. Finally, Turkey participated in PISA examination in 2018, and had a mean score of 454 and ranked 42nd in mathematics literacy among 79 countries, while ranked 33rd among the 37 OECD countries (MoNE, 2019c; Schleicher, 2019).

Similarly, Turkey's mathematics achievement scores and rankings in TIMSS examinations were not satisfactory. As demonstrated in Table 1.3 below, Turkey participated in TIMSS in the years 1999, 2007, 2011, 2015 and 2019. The results of TIMSS 1999 revealed that Turkey had a mean score of 429 in mathematics, and ranked 31st among 38 participating countries (MoNE, 2003). According to TIMSS 2007 results, Turkey had a mean score of 432 in mathematics achievement and ranked 29th among 59 countries participated in the study (MoNE, 2011). In 2011, Turkey participated in the TIMSS both with fourth and eighth graders. According to TIMSS 2011 results, Turkey had a mean score of 469 in mathematics achievement for the fourth grade, and it ranked 35th among 50 participating countries; while it got a mean score 452 and ranked 24th among 42 participating countries for the eighth grade (MoNE, 2014a). Similarly, Turkey participated in TIMSS 2015 with fourth and eighth-grade levels. Turkey had a mean score of 483 in mathematics achievement for the fourth grade and it ranked 36th among 49 participating countries; while for the eighth-grade level, the mean score of Turkey was 458 and the ranking was 24th among 39 countries (MoNE, 2016). Finally, Turkey participated in TIMSS-2019 with fourth and eighth grade levels. Turkey had a mean score of 523 in mathematics achievement for the fourth grade and it ranked 23rd among 58 participating countries; while for the

eighth-grade level, the mean score of Turkey was 496 and the ranking was 20th among 39 countries (MoNE, 2020b). For the first time in TIMSS-2019, Turkey achieved a score above the median value at the fourth-grade level in mathematics achievement (MoNE, 2020b; TEDMEM, 2021).

Table 1.3

Turkey's Mathematics Achievement Scores in TIMSS by Years

	1999	2007	2011		2015		2019	
Grade Level	8th	8th	4th	8th	4th	8th	4th	8th
General Mean	487	450	500	500	500	500	500	500
Turkey's Mean	429	432	469	452	483	458	523	496
Ranking	31	29	35	24	36	24	23	20
# of Countries	38	59	50	42	49	39	58	39

When we look at the research which investigate the interaction between motivation and academic achievement and which one is a cause or effect on the other, Csikszentmihalyi and Mei-ha Wong (1991) advocated that although most of the research on academic performance include cognitive factors rather than personality and motivational factors, “the problem was not that students could not learn the material, but not want to learn it” (p. 437). People are not like computers that follow some logical steps and as long as the necessary software are set up. People think logically only when they feel like it. Thus, emotional and motivational problems of students rather than intellectual ones form the basis of their educational failures (Csikszentmihalyi, 1990b; 2014a). Many theorists emphasize that motivation has important roles in all learning types, and motivation provides an energy source that enables behavior to occur (Yaman & Dede, 2007). However, motivation variable was not emphasized enough in instructional design studies and has become a neglected subject (Chan & Ahern, 1999; Joo, Oh, & Kim, 2015; Linnenbrink-Garcia, Patall, & Pekrun, 2016). In many studies on education and instruction, it is emphasized that

affective features are at least as effective as cognitive features in predicting academic achievement (Akben-Selçuk, 2017; Khodadad & Kaur, 2016; Nasihah & Cahyono, 2017; Schneider & Bös, 1985). Therefore, what educators and instructional designers should do is to design and implement instruction that will enable the acquisition of affective characteristics as well as cognitive attainments.

It is inevitable for students to develop negative emotions towards mathematics because of thoughts that they will have difficulty and cannot achieve in mathematics. The reason why students fail in math may be that the teaching methods appear to work well in the lab, while they have unexpected consequences in real life. Although children may learn a new way of doing math in controlled setting, they may completely ignore the same material when they are presented in the classroom due to the lack of motivation (Csikszentmihalyi, 1990b). The studies in the existing literature support this notion. Mathematics is seen as one of the subjects towards which many children or adults have anxiety (Turner & Meyer, 2009), it is thought as a boring, unlovable, abstract, and fearful discipline (Aksu, 1985), and it is associated with other negative beliefs which were developed during school years (Grootenboer & Marshman, 2016).

Since it is often observed that students perceive mathematics as a difficult lesson, fear it, and worry that they will fail, researchers make use of various theories to work to eliminate these negative feelings of students, increase their motivation, and enable them to learn subjects better. It is known that the first impressions created for individuals in mathematics have a significant impact on their perspective towards mathematics in the future (Çakmak, 2005). Hence, it is recommended that teachers should use activities which attract students' interest especially beginning from elementary grades. For example, Daniels (2010) stated that teachers can provide motivational learning environments in order to help learners be motivated. Similarly, Gelman and Greeno (1989) found out that students can be taught new mathematics concepts more easily when they are motivated by their teachers.

There is various research in relevant literature about why and how motivation is important in education. While some of the studies aimed at determining the effect of a specific teaching technique that applied for a lesson or subject on students'

achievement and motivation, others aimed at revealing how motivation and academic achievement relate to each other (Batdı & Semerci, 2016). Niehues, Kisbu-Sakarya and Selcuk (2020) compared Turkish students' average scores of motivational beliefs with OECD average, using PISA-2012 data. Accordingly, the findings indicated that the mathematics self-efficacy beliefs of Turkish students did not significantly differ from that of OECD mean, while Turkish students had lower self-concept beliefs and higher interest in mathematics. In addition, the results obtained from TIMSS-2019 have determined that Turkish students who value mathematics highly achieve the highest mathematics score, but students who do not value mathematics achieve low in it. Similarly, when the averages of both Turkish students and all the nations participating in the exam are investigated, it is revealed that the students who love mathematics had the highest mathematics success (TEDMEM, 2021).

Recently, some researchers aimed to investigate the use of various motivation theories in educational environments. For example, it is seen that Flow Theory is employed in many different fields besides education, such as psychology, sociology, anthropology, religion, business, sports, tourism, leisure, music, games and entertainment, computers and technology (Admiraal, Huizenga, Akkerman & Dam, 2011; Altıntaş, Aşçı & Çağlar, 2010; Aremu & Adebago, 2016; Armstrong, 2008; Karaca, 2018; Li, 2019; Liu, 2019; Millus, 2020; Montanez, 2011; Neitz & Spickard, 1990; Özçiriş, 2017). According to Flow Theory, regardless of the wide-ranging participants, activities, cultures, age or gender, individuals mentioned some common characteristics such as autotelic experience that increase motivation of individuals to look for new challenges (Chan & Ahern, 1999; Montanez, 2011). In other words, if any activity proposes the structure including the conditions “perceived challenges that stretch existing skills, clear goals, immediate feedback, intense concentration, merging of action and awareness, loss of self-consciousness, sense of control, distorting sense of time and intrinsically rewarding experience” (Nakamura & Csikszentmihalyi, 2002, p. 90), then such activities help to increase the willingness to repeat or continue an ongoing activity, since the individuals enjoy doing that activity (Chan & Ahern, 1999).

As there is still much to be learned especially in the design of mathematics education, Norman's (1993, p.32) question seems to be considerable: “Is there some way of

achieving this state of flow while learning?”. Hence, investigating how to utilize Flow Theory in learning and teaching mathematics calls for close examination. Since Flow Theory is essentially a theory of motivation, there are not enough empirical studies yet on how to apply it in an instructional design. According to the relevant literature, it can be inferred that the principles which form the basis of the Realistic Mathematics Education (RME) approach and the principles of Flow Theory support each other (Heuvel-Panhuizen, 2000; Jackson & Csikszentmihalyi, 1999; Jackson & Ecklund, 2004; Schweinle, Meyer, & Turner, 2006; Üzel, 2007; Heuvel-Panhuizen & Wijers, 2005). Therefore, an instruction designed based on Flow Theory and enhanced with Realistic Mathematics Education might be effective on providing students with enjoyable, engaging and motivating learning environments. In other words, although Flow Theory has certain principles and elements, a tangible guide is needed for these principles to be used in an instructional design. Therefore, it may be possible to design a mathematics instruction that will positively contribute to students' learning both emotionally and cognitively if the principles of Flow Theory can be integrated with RME which has supportive characteristics and principles with and emerged as a specific mathematics education approach.

As RME approach argues, mathematics is a human activity, and people have been discovering mathematical concepts in line with their own interests, needs and used them to meet their daily needs (Heuvel-Panhuizen & Drijvers, 2014). Therefore, in mathematics teaching, it is essential that these concepts be taught by creating learners' own mathematical models, in accordance with their own prior learning and level of knowledge, making use of real-life problems which are similar to those in the historical process (Arseven, 2010). These are compatible with the principle of Flow Theory, that the activity is suitable for and balance with the perceived abilities of the individual, and that the level of skill increases as the challenge increases. Accordingly, individuals have more intrinsic motivation when participating in activities that are suitable for their own learning pace and ability level (Csikszentmihalyi, 1975b).

While the first studies on Flow Theory were conducted, the researchers carried out the research based on the intrinsic motivation elements put forward by different motivation theories. However, among these precursor theories, Callois's (1958)

approach, which deals with the intrinsic motivational aspects of the game or play, was more effective in forming the structure of Flow Theory about autotelic activities (as cited in Csikszentmihalyi, 1975). Accordingly, people have pleasure in play-like activities which help them test their boundaries, enhance abilities, experience, and explore new things, have a feeling of discovery and solve the problems (Engeser & Schiepe-Tiska, 2012). In other words, in educational activities, things that need to be done to motivate students to learn and to make them enjoy learning are not different from these aspects that make playing a game attractive, fun, and intrinsically motivating (Norman, 2003). For this reason, the realistic tasks used in the RME approach are able to reflect the characteristics of the play-like activities on which Flow Theory is based and can be effective in providing the learners' intrinsic motivation. In RME, students are presented with problem situations that they may encounter in real life. These problems are designed in a way that requires learners to help each other, to imitate various people and characters (for example to be like a carpenter, a cashier, an engineer, or a scientist etc.), to role play, to think like those people, and to be physically active like playing house.

Another common feature of the Flow Theory and the RME approach that supports each other is that it is important to clearly define the goals to be achieved in both approaches. In RME, the point to be considered while creating the problem situations that will enable learners to explore the concepts in a similar way to the historical process is that the problem situations ensure reaching the predetermined goals in the most accurate way. For this reason, the objectives of each stage in solving the problem should be clearly and comprehensibly determined (Heuvel-Panhuizen, 1996). Thus, it is aimed that students first create their own non-formal models (*model of*) and then reach a more abstract and formal mathematical model (*model for*) based on the non-formal models (Gravemeijer & Doorman, 1999). Similarly, Flow Theory argues that activities with clear objectives will be more effective in making individuals experience the flow state. That's why people are more likely to experience flow when participating in play-like, spiritual or sports activities which have predetermined goals and rules (Csikszentmihalyi, 1994).

Additionally, according to Flow Theory it is crucial that individuals should have access to clear and immediate feedback during the activity, to check their own development or progress, and refer to when they get stuck (Reeve, 2009). Therefore, in educational environments, elements such as interaction and cooperation between students are very important in order to provide feedback which is conducive to experience flow state (Sawyer, 2015). Similarly, interaction among students is considered as one of the most effective factors in increasing motivation in the RME approach (Treffers, 1991; Uyen, Huu Tong, Phu Loc, & Thanh, 2021).

Chan and Ahern (1999) states that Flow Theory has features to establish the link between the requirements of instructional and motivational design approaches. For instance, the researchers advocate that while instructional design benefits more from behavioral and cognitive psychology, Flow Theory can also expand the motivation dimension in instructional design by incorporating elements of humanistic psychology. Flow activities have specific structural properties in common. It is possible that these properties could be integrated in any situation if it is designed appropriately (Csikszentmihalyi & Csikszentmihalyi, 1988). In fact, many existing studies in the literature prove that the facilities of the flow are applied in various fields. However, there are very few studies on how Flow Theory principles can be applied in an instructional design which affects the flow state, motivation and academic achievement in education, and more specifically in mathematics teaching. Although many of the properties related to flow are important when understanding the concepts in mathematics as well, only a small number of students are able experience mathematics in this way (Sedighian, 1998).

Therefore, in the light of these, it is safe to say that there is a need to design and apply instruction to increase students' knowledge and skills related to motivation and academic achievement in mathematics, by making use of the experimental studies and practical usage of RME approach in the designing of instruction especially for the mathematics, integrating them into the Flow Theory. Thus, the current study was conducted to experimentally test how the instruction designed based on Flow Theory principles and RME approach effect students' motivation, flow state, achievement and retention in mathematics. From this point of view, it was expected that affective

characteristics such as mathematics motivation and flow experience, and academic achievement and retention in mathematics can be enhanced by using the Flow Theory principles. Moreover, the researcher aimed to determine the opinions of students about the instruction designed based on Flow Theory principles and RME approach.

1.2. Purpose of the Study

In this study, it was aimed to design and implement mathematics instruction for the fifth-grade students based on the principles of Flow Theory and enhanced with Realistic Mathematics Education, and to investigate the effects of this instruction on students' achievement, retention, flow state and motivation. Based upon this main purpose of the study, the following research questions were formulated:

1. Is there any significant difference between the Mathematics Achievement and Retention scores of students in the experimental and control group?
2. Is there any significant difference between the Flow State scores of students in the experimental and control group?
 - a) Is there any significant difference between the Flow subdimension scores of students in the experimental and control group?
 - b) Is there any significant difference between the Boredom subdimension scores of students in the experimental and control group?
 - c) Is there any significant difference between the Anxiety subdimension scores of students in the experimental and control group?
3. Is there any significant difference between the Mathematics Motivation scores of students in the experimental and control group?
4. What are the opinions of experimental group students about the treatment?

1.3. Significance of the Study

It is expected that this study will make significant contributions to the literature in many ways. Especially in our country, various studies indicate students' dislike of mathematics, low achievement and self-confidence, high anxiety towards mathematics and varying levels of mathematics hopelessness (Ev, 2003; Gündüz Çetin & Saracaloğlu, 2021; TEDMEM, 2021). Since students could not comprehend the abstract concepts, they fear being unsuccessful which in return causes students to abstain from mathematics lessons (Ateş & Bozkurt, 2021; Demirdöğen, 2007; Kennedy, Tips, & Johnson, 2008). Although the importance, benefit and effectiveness of mathematics are known by people from all strata, there is a widespread understanding among the learners that mathematics can only be learned by intelligent or genius people, doing mathematics is a monotonic, boring and useless process. Some of the most important reasons for such opinions about mathematics are that math lessons become more abstract after primary school as they become distant from daily life, intensive and strict characteristics of mathematics curricula, and some negative behaviors of teachers (Yıldırım, 2009).

When we look at international exam results, as well as Turkish students' poor performance in mathematics, an existing table appears worse in terms of affective characteristics. For instance, in PISA-2003 it is reported that more than 25% of Turkish students have high level of anxiety in mathematics, which brings down their mathematics performance about one standard deviation or 100 points (MoNE, 2005). Similarly, PISA-2012 results showed that 65% of Turkish students reported having skipped classes or days of school and mathematics beliefs were below the OECD mean (OECD, 2014). Additionally, according to TIMSS 2019 results, the rate of eighth grade students who are very confident in mathematics was 15%, while the rate of students who are not confident was 50% (TEDMEM, 2021).

The study conducted by Akben-Selçuk (2017) found out that students' personality and motivation have significant effect on their mathematics achievement. That is, individuals who are more open to activities such as problem solving perform significantly better. In the study of Üredi & Üredi (2005), the results revealed that the

motivational beliefs and self-regulation strategies significantly predicted the mathematics achievement. Moreover, students who have more intrinsic motivation tend to achieve better in mathematics, because of enjoyment and personal interest that they have in the subject. On the contrary, motivating students extrinsically during mathematics lesson does not help students achieve more when compared students who have less extrinsic motivation (Akben-Selçuk, 2017).

In order to help students to better understand and achieve in mathematics, teachers should prepare effective learning environments in which students are intrinsically motivated towards learning mathematical concepts, engaging tasks and activities. According to Glasser (1986), students choose to perform and excel in tasks that are enjoyable for them. In other words, enjoyment and fun are powerful components in learning in the classroom. Instruction designed based on Flow Theory principles and RME approach can provide such components as they help students enjoy what they are doing, put all their effort into it, and the endeavor becomes intrinsically motivating (Challco, Andrade, Borges, Bittencourt, & Isotani, 2016; Csikszentmihalyi & Nakamura, 2014). Additionally, applying such instruction provides learners to participate in appealing tasks which attract their interest, allow them to learn meaningfully, retain knowledge and be able to relate the concepts with real life situations (Altun, 2006; Bintaş, Altun & Arslan, 2003; Fauzan, 2002; Heuvel-Panhuizen & Drijvers, 2014)

Previous studies related to flow investigated the relationship between flow state and experiences in which participants report a balance between challenges and abilities, as well as other outcome variables asserted in Flow Theory (Ak-Şentürk, 2010; Alperer, 2005; Baydaş, Karakuş, Topu, Yılmaz, Öztürk, & Göktaş, 2015; Inal & Çağıltay, 2007; Kirchhoff, 2013; Sillaots, 2014). However, there are very few experimental studies which investigate the effect of using flow in instruction (Aydın, 2005; Hamari et al., 2016; Mannell & Bradley, 1986). In fact, there is hardly any study that investigates the use of Flow Theory in mathematics instruction experimentally (Aremu & Adebagbo, 2016). On the other hand, it is possible to come across several empirical research about the use of RME in instruction and examining its effects on various variables such as achievement, retention, and several affective characteristics

(Erdoğan, 2018; Fauzan, 2002; Forehand, 2014; Laurens, Batlolona, Batlolona, & Leasa, 2018; Yonucuoğlu & Bindak, 2021; Zakaria & Syamaun, 2017). For this reason, it can be thought that this study might contribute to both the practice and the literature as it is the first study to examine the effects of two approaches that support each other theoretically by integrating them into the design of mathematics instruction.

Making use of flow principles includes the state of inner and outer awareness which increases learners' resilience, creativity, openness to new ideas, and attentiveness (Parr, Montgomery, & DeBell, 1998). There are three reasons for selecting Flow Theory as the main focus for this study. First, the flow experience suggests considerable aspects for a quality environment for learning such as clearly stated goals, balance of perceived skills and challenge, immediate feedback, autonomy, and concentration. Then, the Flow Theory helps us to handle affective facets of the learning such as boredom, anxiety, apathy and pleasure, which might affect individuals' learning. Third, flow experiences support individuals to participate in the activities intrinsically due to their autotelic attributes. That is, if a person enjoys doing something, he or she most probably will want to come back and do it again. In addition, the Flow Theory strengthens individuals' awareness that they have choices related not only to education, but to their personal lives as well, which allows them to experience ownership of their lives (Montanez, 2011). When individuals are accountable and pursue a sense of awareness, they are empowered to commit to certain goals that allow them to develop further in their interests and skills (Parr et al., 1998).

Additionally, instructional practices of RME emphasize that students who learn mathematics by starting from real life problems provide meaningful learning by creating mathematical concepts, making use of models according to their own thinking skills and background knowledge (Altun, 2006; Erbaş, Kertil, Çetinkaya, Çakıroğlu, Alacacı, & Baş, 2014; Treffers, 1991; Yağcı & Arseven, 2010). In addition, when RME is applied in instruction, individuals realize the benefit and real-life use of mathematical concepts (Üzel, 2007). This situation both attracts their attention to mathematics subjects and enables them to participate in learning activities more willingly. Since the problem situations used in RME require students to complete some tasks that include their interests and needs in daily life, to cope with problems and to

produce solutions by creating their own models, they play a role in meeting the need to have fun and play-like activities which form the basis of Flow Theory. Therefore, this study provides helpful results for teachers while preparing and regulating their lessons in which students enjoy, willingly participate in the learning tasks, value mathematics, and help them to achieve. It can also provide experts, curriculum developers, and other stakeholders who design curricula for mathematics courses with a beneficial system for designing their criteria in selecting, assessing, and fine-tuning assignments. Thus, results from this study may be used in enabling learners to change their attitudes towards mathematics and activities used in mathematics teaching. Finally, in this study, an adaptation study was carried out to determine whether Flow State Scale developed by Eryilmaz and Mammadov (2016a) is suitable for fifth grade students and a mathematics test was developed by the researcher in accordance with the test development stages, which might be considered as other contributions to the literature.

1.4 Definition of the Terms

Mathematics Motivation: “The psychological mechanism determining the direction, intensity, and persistence of individuals' activity” (Kanfer, 1994, p. 330) that individuals have towards doing mathematics, participating mathematics activities, learning concepts and problem solving processes.

Flow State: “A self-justifying experience which is intrinsically rewarding and leads the individual to seek replicate flow experiences that introduces a selective mechanism into psychological functioning that fosters growth” (Nakamura & Csikszentmihalyi, 2014, p. 244-250).

Flow: “The subjective buoyancy of experience when skillful and successful action seems effortless, even when a great deal of physical or mental energy is exerted” (Shernoff & Csikszentmihalyi, 2009, p. 132).

Anxiety: “The resulting stress experienced when a person believes that his action opportunities are too demanding for his capabilities” (Csikszentmihalyi, 1975a, p. 49).

Boredom: “The state of feeling results when skills are greater than opportunities for using them” (Csikszentmihalyi, 1975a, p. 49).

CHAPTER 2

LITERATURE REVIEW

In this chapter, a review of the literature on motivation, Flow Theory, Realistic Mathematics Education, and their importance in education and mathematics teaching was discussed. The background of Flow Theory, basic principles, definitions, areas of use, and examples of educational applications was included. In addition, motivation theories, types of motivation, which are mostly used in education will be presented in this section. Related research studies about Flow Theory and motivation was also included in this chapter.

2.1. Motivation

The current theory and research about motivation field have been shaped by important trends especially in the last century. These trends have shifted from theoretical perspectives of “unconscious motives, drives, and rote behaviors to current theories that consider cognitive, social, and developmental aspects of motivation” (Anderman & Dawson, 2011, p.222). The motivation of learners to participate in the activities has been handled by many social-science researchers so far (Keller & Bless, 2008), although the amount of attention that given to motivation at educational settings fall behind academic achievement of students (Shernoff & Hoogstra, 2001). However, there exist strong evidence that low-level student motivation might be responsible for ill-advised behaviors such as leaving the school, lower participation, getting bad marks and discipline problems (Yazzie-Mintz, 2010). Therefore, it is crucial for students to have positive attitudes and thoughts toward learning in order to increase their achievement (Elma & Bütün, 2015).

It has been proven in much educational and psychological research that motivation has multiple roles for carrying on educational goals (Boekaerts, 2001). In fact, there exist lots of research that advocate the motivational attributes are affective in predicting students' achievement in different subjects (Akbaba, 2006; Akben-Selçuk, 2017; Khodadad & Kaur, 2016; Nasihah & Cahyono, 2017; Yuan-Bing, 2011) since motivational approach and studies could be used in instructional designs at every grade level to enhance achievement of learners (Anderman & Dawson, 2011). Moreover, the investigations have shown that the amount of variance in achievement that is predicted by cognitive factors is about 50%. However, this proportion is decreased to about 25%, if the factors related to motivation are statistically ignored (Schneider & Bös, 1985).

There are different definitions of motivation in many different fields. In general, motivation is defined as “the psychological mechanism determining the direction, intensity, and persistence of individuals' activity” (Kanfer, 1994, p.330). It is the driving power that helps students to achieve, study hard at school and learn (Martin, 2001). If a person does not feel any impulse or inspiration to do something, then he is said to be unmotivated. On the contrary, when a person is pushed towards a goal, he is characterized as motivated (Ryan & Deci, 2000). Another definition for motivation emphasizes all the internal and external conditions that awaking, maintaining, and controlling the learners' behaviors (Martin & Briggs, 1986). Motivation also has effects on students' enjoyment and interest when they study on various tasks or subjects (Martin, Marsh, & Debus, 2003). Motivation is a strong determinant on the students' problem-solving skills and giving an outstanding performance on their works (Pressley, El-Dinary, Marks, & Stein, 1992). In a similar way, Reece and Walker (1997) lay emphasis on motivation in education saying that a student with less ability but highly motivated can be more successful than the one who is brighter but less motivated.

According to Csikszentmihalyi (2014a), the reason for failure of children is motivational, not intellectual. In other words, the problem is that students do not want to take part in, they do not wish for learning; rather than they do not understand or cannot cope intellectually with school. The present definitions of motivation have been formed to emphasize the learners' cognitions and values about school experiences,

learning (Eccles, Wigfield, & Schiefele, 1998) and school engagement in terms of intellectual, behavioral, and affective aspects (Fredricks, Blumenfeld, & Paris, 2004). School engagement does not mean attending school only or sitting in the classroom without any profit from learning activities. Cognitive school engagement, for example, implies the level of intellectual effort which individuals endeavor to accomplish the challenges, activities or learning goals in the classroom. Investigations prove that students who have high academically achievement tend to make use of more cognitive strategies than less-successful ones (Pintrich & De Groot, 1990). Behavioral engagement, on the other hand, refers to learners' taking initiative, responsibility, conforming classroom rules/norms, attending constructively and cooperatively in the classroom (Buhs & Ladd, 2001; Finn, 1993). Some studies advocate that behavioral engagement antecedes students' scholastic success in school (Ladd, Herald-Brown & Kochel, 2009). Emotional engagement is characterized as attitudes and sentiments of individuals toward school affairs or context. Emotional engagement has attributes that highly correlate with both behavioral and cognitive engagement, thus it is hard to distinguish its predictive contributions to achievement (Ladd, Herald-Brown & Kochel, 2009).

The motivation that people have not only varies in degree, but also in types as well. The type refers to the orientation of motivation, which relates to the basic attitudes and goals that cause the actions (Ryan & Deci, 2000). According to Self-Determination approach, motivation types differ due to various reasons and goals that lead to action. However, the most common and basic distinction has been made between the two types: Intrinsic and extrinsic motivation (Deci & Ryan, 1985).

2.1.1. Intrinsic motivation.

Intrinsic motivation is the type of motivation in which learning needs and feeling of achievement occur in natural conditions (Ryan & Deci, 2000). Intrinsically motivated individuals usually find personal interest when they do something. That is, they go on doing the activity for its own sake, not for a reward offered extrinsically (Deci & Ryan, 1985). Intrinsic motivation helps students to obtain feelings of satisfaction, improved competence, and self-determination (Akbaba, 2006; Deci & Ryan, 1985). The

curiosity, the need to know, and the desire to be sufficient and developed are some examples of intrinsic motivation (Akbaba, 2006).

The research on motivation has demonstrated that intrinsic motivation can be promoted through both classroom and home environments by promoting learners' autonomy and competence needs (Ryan & Deci, 2000). If goals help students to attend more in the enjoyable activities competently, then they can enhance intrinsic motivation through this competence valuation process (Elliot & Harackiewicz, 1994). Moreover, giving the opportunity of choice and self-direction has positive effects on intrinsic motivation (Zuckerman, Porac, Lathin, Smith & Deci, 1987). On the contrary, when one feels non-autonomy and has incompetency, intrinsic motivation is said to be declined. Activities which cannot attract individuals' self-interest or those which do not have the appeal of originality, challenge and aesthetic value for the learners, should be investigated on the basis of extrinsic motivation (Ryan & Deci, 2000).

2.1.2. Extrinsic motivation.

Extrinsic motivation includes the effects outside of the individual. For example, if students are praised and reinforced after they take high grades from the exam, this motivates the students extrinsically (Akbaba, 2006). In other words, extrinsically motivated individuals participate in the activities in order to get some external expectations such as awards, money, prizes, grades etc. or avoid punishment such as bad marks (Deci & Ryan, 1985). In extrinsic motivation, individuals focus only on what they will obtain at the end, rather than the pleasure taken from learning new things (Akbaba, 2006). Extrinsically motivated learners might behave in two ways: In the first and the more commonly encountered case, they may attend to activities with feelings such as anger, disinterest and reluctance, as they might be forced to participate in the action. However, in the second case, the extrinsic goal may become charming since it is adopted through the sense of demanding (Ryan & Deci, 2000).

Self Determination Theory advocates that extrinsic motivation has different types in itself, some of which might cause effective states and autonomy. That is, the types of external motivation from least autonomous to the most are external regulation, introjection, identification, and integration (Ryan & Deci, 2000). The relationship

between the two types of motivation has been debatable issue among the researchers. In classic literature, extrinsic motivation has generally been understood as ineffective or poor type of motivation, and it is said to be always strictly non-autonomous when compared with intrinsic motivation (De Charms, 1968). According to Ryan and Deci (2000), the use of threats, deadlines, directives and competitive pressures have effects on the reduction of intrinsic motivation. In fact, the concrete rewards, reinforcement and awards given to individuals in order to enhance their motivation in any kind of task lead to reduce their intrinsic motivation (Hayamizu, 1997), since those incentives are perceived as controllers of the behavior. In contrast, there exists another group of view which advocates that extrinsic motivation does not cause any decrease in the intrinsic motivation (Cameron, Banko, & Pierce, 2001). However, the activities or tasks that the learners attend may not always be innately attractive or enjoyable. As a result, teachers should know how to apply more affective types of extrinsic motivation in order to provide successful learning environments (Ryan & Deci, 2000). Some of the researchers argue that both type of motivation should be used appropriately in order to help students to effort on the activities (Gürdoğan, 2012).

2.2. Flow Theory

The concepts of flow or optimal experience were developed by Csikszentmihalyi (1975a) based on the notion that “intrinsically motivated, or autotelic, activity that rewarding in and of itself, which is quite apart from its end product or any extrinsic good that might result from the activity” (Nakamura & Csikszentmihalyi, 2002, p.89). This approach differs from other motivation theories which look to the past and to the future for the key to motivation, as it is more interested in what pushes people to embark or go on a task since they are pleased in its performance at that moment. In other words, Theory of Flow does not ignore the feelings of individuals while acting, but other theories of motivation pay no attention to the processes but care about the outcomes, in order to clarify the justification of the action (Csikszentmihalyi & Rathunde, 1992). The term of flow has the meaning of an optimal state of mind that one feels cognitive efficiency, highly motivated and deeply engaged in the experience, and enjoy what they are doing (Csikszentmihalyi, 1975a).

Using extrinsic rewards as the only drive to reach the desirable goals had made some investigators worry, since they might have some unseen dangers on individuals' behaviors. The more an individual adheres to extrinsic rewards, the less he enjoys in the work, and the more extrinsic rewards he needs. The only way to break such a vicious circle is getting people attend in tasks that are more enjoyable by themselves (Csikszentmihalyi, 1975a). Being inspired from this point of view, Csikszentmihalyi and colleagues decided to explore activities which include rewards within themselves. The researchers focused especially on the individuals who participate in activities such as games and play that might include remarkable intrinsic rewards (Nakamura & Csikszentmihalyi, 2002). They tried to explore the explicit characteristics of leisure activities and then apply those characteristics to make enjoyable work environments which decreases dependence on extrinsic rewards. (Csikszentmihalyi, 1975a). Later, researchers realized that not only games-like, but also some other activities may have motivating elements in themselves, and the question "why would people want to participate in dangerous, time-consuming and difficult activities although there is no tangible external reward?" puzzled the researchers and forced them to do research (Csikszentmihalyi & Rathunde, 1992: p. 58). When revealing the concept of flow, investigations were maintained between early 1980s and late 1990s in different countries (Csikszentmihalyi and Csikszentmihalyi, 1988; Massimini & Carli, 1988; Nakamura & Csikszentmihalyi, 2002). During this period, the concept of flow has been drawn interest of many researchers from formal schooling at all levels to outside academia such as business, sports and politics (Nakamura & Csikszentmihalyi, 2002).

When investigating the flow concept, the researchers first applied trial interviews with about sixty individuals from various sports branches including swimmers, climbers, team players (Csikszentmihalyi, 1990b). Using the data obtained from these interviews, they prepared a questionnaire and a more structured interview form and applied these to other respondents who participate in autotelic activities (Csikszentmihalyi, 1975a). Such activities create order in individuals' minds, have more chance of being remembered, and they are most likely to be repeated (Sedighian, 1998). These groups of individuals ranging from beginners to professionals include chess players, composers of modern music, dancers, basketball players, surgeons, teachers and a number of other respondents were selected in order to understand what

motivates individuals to participate in activities which are challenging (Csikszentmihalyi, 1975a).

The results obtained from interviews and questionnaires have put forward that all individuals attend in autotelic experience. The term “autotelic” is come into existence by combining the two Greek concepts “auto (self)” and “telos (goal)”, which refers to the activities rewarding in and of itself (Nakamura & Csikszentmihalyi, 2002, p. 89), and “requires formal and extensive energy output on the part of the actor” (Csikszentmihalyi, 1975a, p. 10). Interviewees’ expressions revealed that the flow experiences have some common features and the necessary conditions were remarkably similar across any type of activity. Although the participants were from different fields, when expressing their feelings during the autotelic activities, most of them used similar terms and the word *flow* as a metaphor in order to describe their experiences or express how they felt when performing the activity (Csikszentmihalyi & Rathunde, 1992; Jackson & Csikszentmihalyi, 1999). As a result, Csikszentmihalyi coined the term *flow* for the autotelic activities in which individuals intrinsically rewarded (Montanez, 2011). From then on, Csikszentmihalyi has exhibited the Flow Theory which is known as the phenomena of human happiness as a product of intrinsic motivation (Blood, 2006).

Flow research and theory are rooted in the investigations of activities that are called as intrinsically motivated or autotelic. Flow describes a state of mind which occurs during the participating in a task that is selected for the own sake of that task and enhances personal growth through challenges of present abilities of individuals (Turner et al., 1998). Flow is defined as peak-like experience in which individual has a sense of involvement and concentration on the moment, while losing the time and consciousness during the activity (Rathunde & Csikszentmihalyi, 2005b). Flow is referred to the actions of individuals such as having fun, being satisfied, happy, and interested in which referred to as optimal experience (Csikszentmihalyi, 1997). In addition, flow represents a state of concentration which includes being totally absorbed and involving intensively in the activity (Keller & Bless, 2008).

The experience of flow does not change in whichever culture, group, sex, age or event it occurs (Nakamura & Csikszentmihalyi, 2002). Today, workplaces and schools, where many people spend a great deal of their time as employees or students, assuming that serious work must be boring and brutal. However, one might have the state of flow in any activity they attend, even at very low-level entertainment activities (Csikszentmihalyi, 1975a). Flow activities are not unusual and scarce since one can observe them in daily-life endeavors as microflow experiences such as driving a car or washing the dishes (Keller & Bless, 2008). In fact, flow state might be observed in addictive, antisocial and nonethical experiences such as gambling, video games addiction, even in crime and warfare (Csikszentmihalyi, 1975a).

Although flow has been investigated in many different fields in everyday life, it is seen especially important in educational environments as well (Shernoff, Csikszentmihalyi, Schneider, & Shernoff, 2003), since it is designated as a helpful theory to motivate students' intrinsically (Csikszentmihalyi, 2000). Flow Theory proposes that intrinsic motivation elements help individuals to enhance psychological state when they have total engagement in learning tasks (Csikszentmihalyi, 1975a). Csikszentmihalyi (1990a) advocates that Flow Theory has the role of guide, wherever there is a need for the improvement of life. Moreover, the most important usage of flow could be in schools and on the job, in which individuals stay most and often feel boredom and anxiety (Csikszentmihalyi & Csikszentmihalyi, 1988). In relevant literature, some studies have revealed that students experienced more flow during academic activities such as learning and reading than other activities (Bakker, Golub & Rijavec, 2015). Hence, Flow Theory can be seen as a guide to reach educational goals, since flow involves the experiences that is seen as optimal due to high pleasure when one attends, and giving importance to the motivation of students during teaching is vital due to its relatedness with many important variables for pupils such as academic achievement (Csikszentmihalyi, 1990a). In addition to intrinsic motivation, experiences of flow also have been cited to increase self-esteem and the actual amount of time spent doing academic work (Hektner & Csikszentmihalyi, 1996).

2.2.1. The Elements of flow.

As with many other psychological concepts, ignorance of the flow does not mean that it is not happening, and knowing about it does not guarantee it will happen in its time. Regardless of this, the more we know about the flow, the more likely we will be able to get students to experience it (Csikszentmihalyi, Latter, & Duranso, 2017). While some people can enter into a flow experience by directing their awareness according to the requirements of the flow, others can experience this through some external signs. In fact, some activities allow experiencing the flow without any effort, while some activities (such as games, art and rituals) seem to be specifically designed for people to experience flow (Csikszentmihalyi, 1975a). Although the activities that provide flow experience differ from the outside, it has been determined that these activities have some common features.

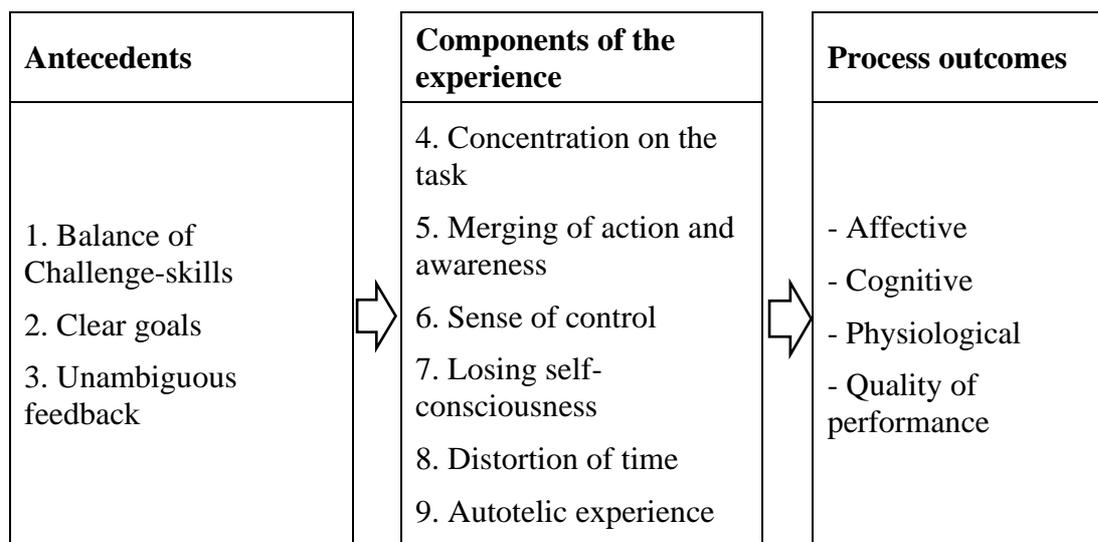


Figure 2.1. Antecedents, components and process outcomes of the flow. Adapted from “Flow and its affective, cognitive, and performance-related consequences” (p. 68), by A. Landhäußer, and J. Keller, 2012. New York, NY: Springer.

Since the conception of flow in the 1970s, researchers have identified that flow has nine elements (see Figure 2.1), three of which are antecedents and six of which are the process outcomes (Csikszentmihalyi et al., 2017). Activities that provide the necessary antecedents and components are effective in obtaining positive results based on affective, cognitive, physiological and performance (Landhäußer & Keller, 2012). There is a dependence and link between these elements observed in every activity that provides the flow experience (Csikszentmihalyi, 1975a). Investigators have revealed that flow exists in a sequential manner. That is, the process starts with the antecedents which are consistency between perceived skills and challenges, distinct goals and clear feedback. Process outcomes which are intense concentration, merge of action and awareness, feeling of control, losing self-consciousness, distortion of time and autotelism occur only if the three antecedents are actualized (Csikszentmihalyi et al., 2017). A detailed explanation of these structures of the flow is given in following sections.

2.2.1.1. Balance of skills and challenges.

The balance between perceived skill and challenges is considered as a distinctly referred condition of flow, regardless of any kind of demographics (Csikszentmihalyi, 1985; Deci & Ryan, 1985). This assumption is seen fundamental because when a balance is achieved between perceived skills and possibilities, individuals are more likely to experience flow (Nakamura & Csikszentmihalyi, 2002; Csikszentmihalyi, Abuhamdeh, & Nakamura, 2005). In other words, enjoyment from the activity is experienced only if individuals have the feelings of their available skills and the task challenges match in the optimal balance (Csikszentmihalyi & Csikszentmihalyi, 1988).

It can be stated that what is called an activity or a task does not have to be active only in terms of physically movement, and what is called a skill does not have to be in terms of physical (Csikszentmihalyi, 1990a). The challenges may also differ according to the goals of each activity. For example, defeating an opponent in tennis requires more physical skill, while in chess it requires mainly intellectual, for a surgeon the challenges include restoring the health of patients (Csikszentmihalyi, 1994).

Enjoyment lies at the area between being bored and anxious where the perceived opportunities and skills can be precisely balanced (Csikszentmihalyi, 1990a). According to Nakamura and Csikszentmihalyi (2002), optimal balance occurs in a flexible manner, which means it is intrinsically fragile, and as the amount of skills or challenge change in time, the flow state might be broken due to unbalanced (see Figure 2.2).

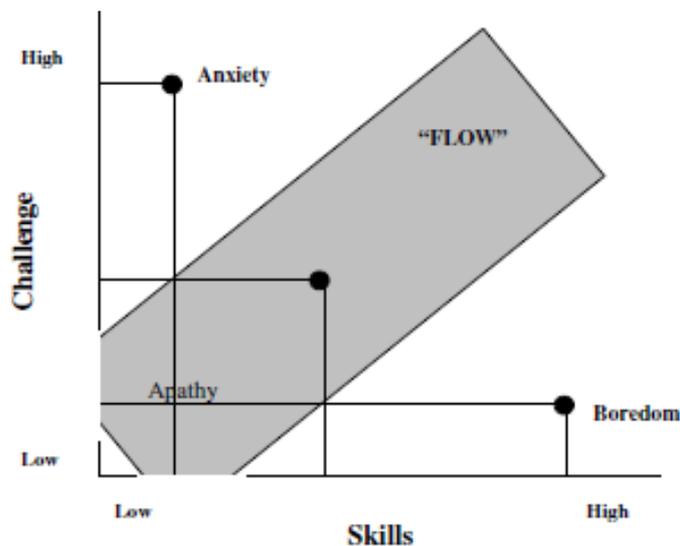


Figure 2.2. Representation of the challenge-skills balance. Adapted from “*Beyond Boredom and Anxiety*” (p. 49), by M. Csikszentmihalyi, 1975a, San Francisco: Jossey-Bass Publishers.

As shown in Figure 2.2, if the individuals are presented tasks that are too much above their skills, then they get into the feeling of anxiety; if the learners are given tasks too much below their skill, then they feel boredom (Csikszentmihalyi, 1975a). When the individuals are bored or anxious, they need to change either his level of skill or challenges related to the activity for getting out of the unbalanced condition and entering the flow state again (Nakamura & Csikszentmihalyi, 2002). In other words, these changes in balance between skills and challenges act as feedback to the environment, thus individuals need to adjust their skill level or challenges of the

activity to move off the present state and enter the flow state again (Nakamura & Csikszentmihalyi, 2002; Csikszentmihalyi, Abuhamdeh & Nakamura, 2005). People who are at the state of anxiety can enter the flow by either reducing challenge or enhancing abilities. However, when both perceived skill and the challenge level of individuals are low, these individuals feel more apathetic instead of flow. That is, the balance between skills and challenge provides flow only when both are above a certain level (Nakamura & Csikszentmihalyi, 2002; Csikszentmihalyi, 1997). It is important to clarify that every activity includes opportunity for action, or challenge which necessitates suitable abilities to carry out. If an individual does not have the right skills, the task will be meaningless rather than challenging for him/her (Csikszentmihalyi, 1990a).

2.2.1.2. Clear goals.

Another basic element that enables the individual to have a flow experience is the clarity of the goals (Csikszentmihalyi, 1990a). Flow experiences generally take place when there are clear goals that individual tries to reach. Most of the games, kinds of sports and religious ceremonies have well-defined rules and goals (Csikszentmihalyi, 1994). These goals are set before starting an activity in order to make clear that individuals know what to do in every step of the tasks. Individuals who are aware of what is expected of them move forward without doubting about their work and actions (Jackson & Csikszentmihalyi, 1999). When the activity has clearly defined goals which meet the needs and interests, they are more likely to engage learners (Assor, Kaplan & Roth, 2002). For example, a tennis player is aware of what to do during the game. The ultimate goals of the two opponents playing chess are evenly clear: To checkmate the king of opponent first. However, choosing trivial goals does not provide enjoyment for the individuals, even if they succeed it. Some may set goals for themselves that will happen in a long time, such as planting and harvesting the fruits. Although this situation requires a long patience, there are individuals who experience great satisfaction when the goal is reached. The goals of some activities cannot be as clear as those of sports activities like tennis. In some creative activities, for instance, the artist should be able to realize that after each brush stroke she approaches the

painting she plans to make, otherwise the individual will not be able to experience the flow (Csikszentmihalyi, 1990a).

2.2.1.3. Immediate and unambiguous feedback.

Feedback is an important factor that shows how well the above-mentioned goals have been achieved. What creates the feedback changes considerably according to the types of activities. However, what makes feedback valuable is not its type, but the symbolic message it contains (Csikszentmihalyi, 1990a). Individuals need clear evaluations whether their performance is competent or not (Reeve, 2009). It is stated that learners might become more concerned and persist in setting goals, if they are provided immediate feedback by their teachers about performances in activities. In addition, receiving clear and immediate feedback helps to enhance both intrinsic motivation and self-efficacy of students (Csikszentmihalyi, 1997). Receiving feedback provides regulation of the state of consciousness and supports the perception of self (Csikszentmihalyi, 1990a). However, if the student is given non-constructive feedback, then his/her motivation diminishes (Csikszentmihalyi, 1997). On the other hand, where the feedback is elaborate, it can help build a richer pathway network to reach the desired information (Bangert-Drowns, Kulik, Kulik & Morgan, 1991). According to Reeve (2009), feedback can come from the task at hand, comparing individual's present performance with previous performances, comparing individual's present performance with others' performances, and others' evaluations.

2.2.1.4. Concentration on the task /Focused attention.

Focusing and concentrating on the activity are important in the existing of flow, because they help individuals eliminate distracters and irrelevant thoughts (Csikszentmihalyi, 1990a; Csikszentmihalyi, 1997). Forgetting the ungrateful features of life and focusing totally on the task protect the individual from unnecessary things that occupy the mind (Csikszentmihalyi, 1990a). For instance, a dancer explains her feelings about the concentration she had during dancing performance, saying that "I have more confidence in myself than at any other time. Maybe an effort to forget my problems. Dance is like therapy, if I am troubled about something I leave it out the door as I go in the dance studio" (Csikszentmihalyi, 2014b, p. 140). This condition is

described in almost similar words in many flow activities. Individuals report that they forget their problems since the intensity of the experience prevents them from thinking about the past or the future (Csikszentmihalyi, 1994).

In many flow activities, there are inducements that help individuals concentrate on the task at hand. These can be competitions (such as sports and games), material earnings (such as gambling) and physical hazards (such as mountain climbing) (Csikszentmihalyi, 2014b). The structure of the games may include some motivational factors that convince the individuals to play the game. All three factors must be properly integrated into the game and used correctly. Otherwise, these artificial incentives can easily distract individuals, causing their concentration to be lost and consequently disrupt the flow (Csikszentmihalyi, 1990a).

2.2.1.5. Merging action and awareness.

One of the most common and distinctive elements of flow is the merge action with the awareness. When someone is experiencing flow, he can be very cognizant of his actions, however he cannot reflect on the act of awareness separately (Csikszentmihalyi, 1975b). Action and awareness merge only if the learner is completely concentrated on the activity. Irrelevant stimuli are excluded from consciousness (Csikszentmihalyi, 2014b). For example, a rock climber is aware of every step he takes, every move he makes, but he is unaware of that awareness. Similarly, an expert chess player describes the feelings during the match as following : “The game is a struggle, and the concentration is like breathing - you never think of it. The roof could fall in and if it missed you, you would be unaware of it” (Csikszentmihalyi, 1975b, p. 46).

People feel so absorbed that activity progresses by itself, and they become unaware of themselves as separate from the activity. It may seem like almost no effort is needed to maintain the activity, but it is far from being so. The challenge of the activity requires the individual to make a more outstanding physical effort or mental concentration (Csikszentmihalyi, 1990a). Moreover, in order for an individual's actions and awareness to merge in an activity, that activity must be at a feasible level. Therefore, people experience more flow in games, rituals and dance-type activities

whose rules are clearly defined and suitable for their abilities (Csikszentmihalyi, 1975b). In daily life, as long as we ask critical questions about the necessity of the tasks we do or how well we do them, it becomes difficult for us to get into the flow state, because of the interruption and being less concentrated. However, in moments of experiencing flow, actions automatically enable us to move forward as if by magic (Csikszentmihalyi, 1990a).

2.2.1.6. Sense of potential control/autonomy.

It is possible to provide environments in which more flow state is produced by designating rules and mutual responsibilities with the learners, and offering the learners opportunities to experience autonomy and self-expression (Whalen, 1997). However, this possibility only arises when the balance of challenge and skill is provided (Csikszentmihalyi, 1994). The sense of autonomy and control not only helps to cope with controlled environments and tasks (Abbott, 2000), but also reduces the fear of failure. On the contrary, it creates a sense of empowerment in activities (Jackson and Csikszentmihalyi, 1999). In some situations that do not include flow, it is very difficult to maintain such a control mechanism over any period of time due to many imponderables (Csikszentmihalyi, 2014b).

In competitive activities such as basketball, chess, and other games, a sense of control emerges from one's own actions and skill to beat one's opponent (Csikszentmihalyi, 1975a). The individuals often see it as a victory over their own limitedness, not over the competitor. However, in some activities, such as dancing, there may not be any competitors to beat. One of the dancers with whom Csikszentmihalyi (2014b) interviewed, expressed her feelings as: "If I have enough space, I am in control. I feel I can radiate an energy into the atmosphere. It's not always necessary that another human being be there to catch that energy. I can dance for walls, I can dance for floors." (p. 142).

2.2.1.7. Losing self-consciousness.

People in the flow state report that they lose self-consciousness (or *loss of ego, self-forgetfulness, transcendence of individuality*), since the delicate balance between

challenges and skills requires to focus on the activity (Csikszentmihalyi, 1994). The awareness of the self temporarily disappears in a flow setting, and there is a feeling of transcending the boundaries of self (Csikszentmihalyi, 2014b; Jackson & Csikszentmihalyi, 1999). Tasks that make the flow happen (such as playing game, ritual activities, arts, etc.) often do not need any kind of negotiation. Individuals do not have to be pushed for using the self to urge on within the activities, since such tasks are supported by freely accepted rules (Csikszentmihalyi, 1975b). If one is deeply involved in the task, self-concerns shift away from the focus of attention (Csikszentmihalyi, 1994).

Forgetting of yourself does not mean that individuals are unaware of their physical reality during the flow experience. In fact, individuals become more aware of internal processes, as can be seen in several activities such as yoga and religious rituals. It is not often that the consciousness of the body or the function of the individual disappears in the flow, but just self-construction. They learn to intervene in the stimulus and response environment (Csikszentmihalyi, 1975b). For example, it is reported that the athletes often become more natural performers, execute instinctively and confidently, when they are free from self-consciousness (Jackson & Marsh, 1996).

2.2.1.8. Altered sense of time.

In the flow state, individuals feel a confusion of time experience, usually feeling that time passes faster/slower than usual. In tasks that take a long time, the feeling of rapid passage of time maintains the person's concentration and focus for as long as necessary (Jackson & Csikszentmihalyi, 1999). Although rare, individuals in flow expressed that time passes very slowly for them in some cases. For example, ballet dancers stated that they felt as if a difficult rotational movement that actually took place within seconds was taking longer than minutes (Csikszentmihalyi, 1990a).

The mechanical time division that governs our daily schedules is a barrier to flow (Csikszentmihalyi, 1994). Many activities that provide flow experience do not have a time-based situation and such activities have their own cadence (Csikszentmihalyi, 1990a). For example, while students at school start looking into a topic that attracts their interest such as artistic works or scientific experiments, the bell designates that a

50-minute period has finished and the next lesson will be skipped. But in the case of flow, the sense of time becomes a natural feature of the entire human experience, instead of being an arbitrary constraint, ignoring what one tends to do and the way they feel regarding it (Csikszentmihalyi, 1994).

However, there are some exceptions which prove the rule. It is known that in some cases where timing is the most important requirement and challenge, people who experience flow can almost completely determine the elapsed time rather than feeling that time is flowing quickly or slowly. For example, it has been determined that a surgeon, who is very successful in his field and sought after in related surgeries, can accurately estimate how much time has passed, albeit with a small margin of error. It was also revealed that people who are interested in running and racing, which are sports where even very small-time frames are of great importance, have similar skills (Csikszentmihalyi, 1990a).

2.2.1.9. Autotelic experience.

The last property of the flow state is its *autotelic* nature (Csikszentmihalyi, 1975), which means that an activity is not carried out in anticipation of future benefit, however, just because the action itself is a reward (Csikszentmihalyi, 1990a). Where most of those aforementioned eight elements are provided in consciousness, the activities being performed tend to be autotelic (Csikszentmihalyi, 1994). These dimensions of flow are interrelated and interdependent. As a result, people can concentrate on their actions and ignore distractions thanks to the flow activity. Since the flow activities have clear and consistent goals, individuals may temporarily omit their identities and several concerns. Therefore, it becomes possible for individuals to gain an intrinsic motivation from their activity, by providing all these conditions (Csikszentmihalyi, 1975).

According to Nakamura & Csikszentmihalyi (2002) experiencing the activity motivates individuals intrinsically. In other words, they want to redo an activity, because it is a great source of pleasure for them (Csikszentmihalyi, 1994). For instance, an experienced climber expressed the autotelic experience with the following statements: “You move up only to keep the flow going. There is no possible reason for

climbing except the climbing itself; it is a self-communication” (Csikszentmihalyi, 1975, p.47).

Since many of the activities we do in everyday life do not carry a reward in themselves, autotelic experiences are very different from what we feel about these activities. Although leisure activities have a relaxing effect for individuals, they are considered a waste of time as they do not require any skills and do not create new action opportunities. Therefore, the life can become a series of boring and anxious experiences for many people. (Csikszentmihalyi, 1990a).

2.2.2. Measurement of flow.

Since flow is a subjective experience, as with many other subjective experiences, it is very difficult to measure the responses that are effective in maintaining the flow state. The fact that the field of psychology does not attach sufficient importance to the measurement of subjective experiences has also been effective in this situation (Nakamura & Csikszentmihalyi, 2002). Most of the studies related flow focuses on the basic principles of the theory, such as the optimal balance of challenges and skill (Alperer, 2005). Conducting interview, subjective measurements and experience sampling method are the most frequently used self-report tools developed to investigate this inherently changeable, self-conscious and subjective phenomenon (Nakamura & Csikszentmihalyi, 2002). First, the flow concept was revealed by the researchers via qualitative interviews. Interviews have been used for collecting extensive and in-depth data about the concept (Mosek, 2017). Second, there are some questionnaires developed by several researchers to measure the flow. For example, Flow Questionnaire (Csikszentmihalyi & Csikszentmihalyi, 1988) presents participants with several sections describing their experience with flow asking a) whether they have had the experience, b) how often, and c) in what activity contexts. In addition, The Flow Scale (Mayers, 1978) was used to assess the difference between when measuring the flow dimensions. Some questionnaires were developed for measuring flow in a specific area. For example, Bakker, et al. (2015) adapted the WOLF scale, which was originally a scale developed to measure the flow state in the work settings, to measure the flow experiences in the educational environment.

According to their study, the adapted scale had a three-factor structure, appropriate internal consistency reliability and construct validity.

Finally, in the late 1970s, researchers studied on developing The Experience Sampling Method (ESM) in order to use in studies related to flow. In this method, participants are given an electronic pager with booklets of questionnaires. Participants receive a signal from the electronic pager at different times during the day. Immediately after receiving the signal, they fill out the questionnaire given to them. This questionnaire includes items measuring perceived difficulty and skill level. The ESM helps researchers to evaluate the flow between different tasks and situations (Baumann & Scheffer, 2010). In addition, since the ESM allows participants to respond spontaneously, it does not force them to remember past experiences (Cavanaugh & Shernoff, 2014).

2.2.3. Flow models.

The state of flow has been reconsidered by different researchers over time in different studies, in fact, different conceptual models have emerged, all of which are based on the idea of the originating theory. As seen in Figure 2.3, it was originally presented that the flow state is seen in all situations in which the perceived ability and opportunities are balanced properly.

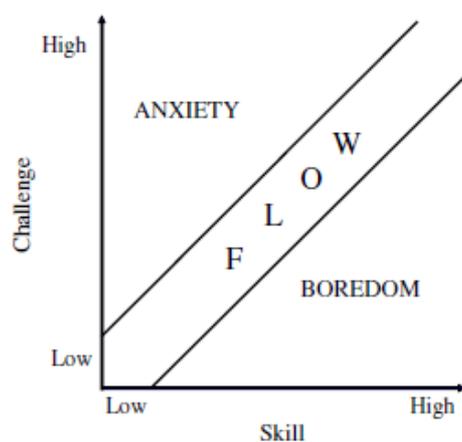


Figure 2.3. Original flow model. Adapted from “*Beyond Boredom and Anxiety*” (p. 49), by M. Csikszentmihalyi, 1975, San Francisco: Jossey-Bass Publishers.

Csikszentmihalyi (1975) described flow operationally in his first model. Accordingly, individuals would enter the flow state when they participated in activity with challenge suitable for their skill level. In the new models developed, the researchers aimed to determine the most appropriate position of the flow state on a two-dimensional table including some other emotional states with the help of different measurement tools. (Dos Santos, Bittencourt, Dermeval, Isotani, Marques, & Silveira, 2018). However, some of the results obtained as a result of subsequent studies by the founder of the theory, as they contained theoretical inconsistencies, forced the researcher to reformulate his model (Csikszentmihalyi & Csikszentmihalyi, 1988). In the reformulated model, the experience of flow could only take place in situations where high levels of difficulty and skills were balanced, not in all equilibrium situations. The model was offered as the *four-channel model* or the *quadrant model* by the researchers (see Figure 2.4, below) (Engeser & Rheinberg, 2008).

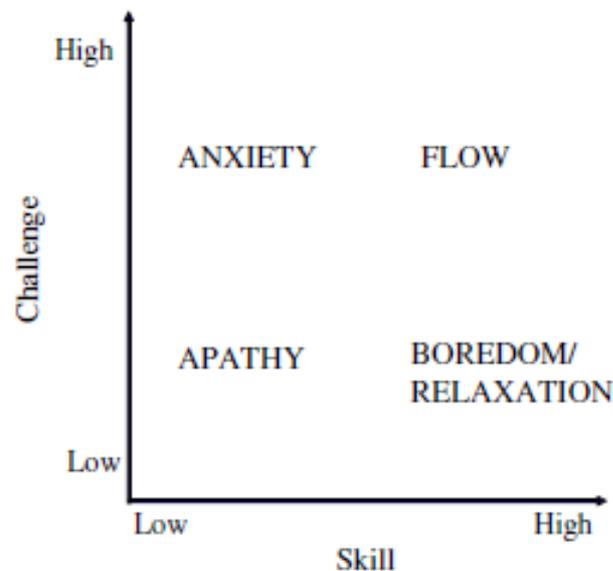


Figure 2.4. Reformulated four-channel model. Reprinted from “*Optimal Experience: Psychological Studies of Flow in Consciousness*” (p. 260), by M. Csikszentmihalyi and I. S. Csikszentmihalyi, 1988, New York: Cambridge University Press.

Later, some deficiency of the experience sampling method was realized by other researchers afterwards. It has been determined that the quality of the experience cannot be optimized if the challenges and skills are simply balanced. Accordingly, Massimini and Carli (1988) determined that flow state occurs if both challenges and skills match at higher levels. That is, if skills and challenges match at lower levels, as in much of TV viewing, the flow does not occur. In the model put forward by Massimini & Carli (1988), the different combinations among the levels of challenge and skill are generated through the eight different channels that represent different emotional states. These eight different situations were depicted visually in eight-channel model (see Figure 2.5) and defined as: “1) High challenge and moderate skill: arousal, 2) High challenge and high skill: flow, 3) Moderate challenge and high skill: control, 4) Low challenge and high skill: boredom, 5) Low challenge and moderate skill: relaxation, 6) Low challenge and low skill: apathy, 7) Average challenge and low skill: worry, 8) High challenge and low skill: anxiety” (Massimini & Carli, 1988, pp. 269-270).

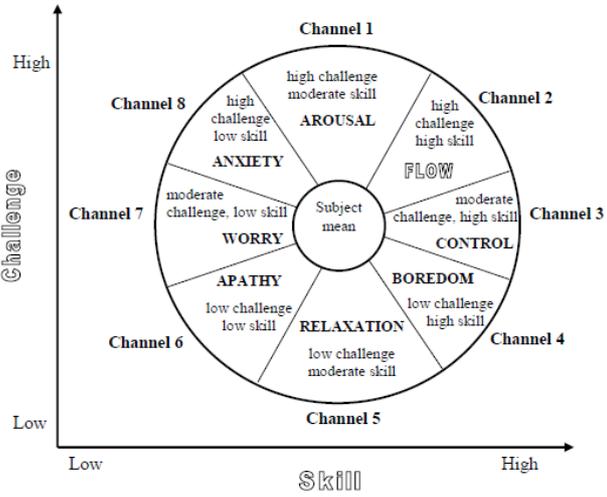


Figure 2.5. Eight-channel model of flow. Reprinted from “*The Systematic Assessment of Flow in Daily Experience*” (p. 270), by F. Massimini & M. Carli, 1988, Cambridge University Press.

Later, some other researchers also contributed to the flow models with different interpretations. Sala (2013), for example, interpreted the flow state by dividing it into small modules called *wold* (see Figure 2.6) (as cited in Dos Santos et al., 2018). This model provides a simpler handling of other flow models by placing each of the flow states in a module.

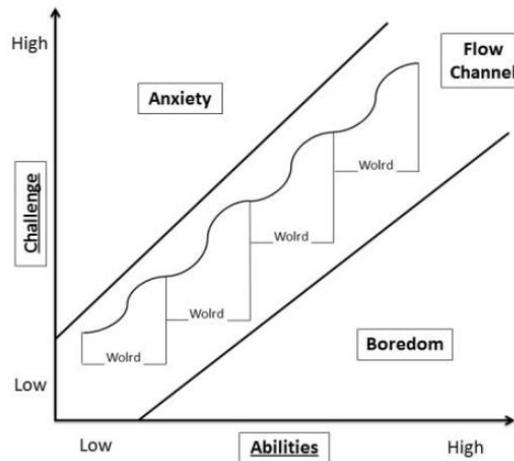


Figure 2.6. The Flow Model of Sala. Reprinted from “Flow Theory to promote learning in educational systems: Is it really relevant?” by W. O. Dos Santos, I. I. Bittencourt, D. Dermeval, S. Isotani, L. B. Marques and I. F. Silveira, 2018, *Brazilian Journal of Computers in Education*, 26, p. 33.

Finally, Schell (2014) proposed a model that differs little from the original model of flow. Accordingly, it is possible for individuals to enter and exit the flow state at each moment of the activity. Moreover, the level of flow experience can vary for each individual during the activity (see Figure 2.7 below).

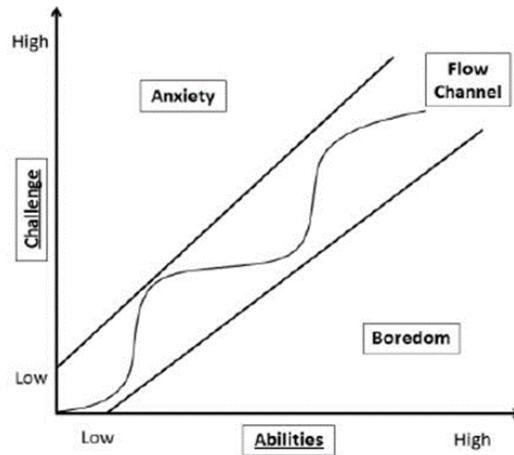


Figure 2.7. The model of Schell. Reprinted from “Flow Theory to promote learning in educational systems: Is it really relevant?” by W. O. Dos Santos, I. I. Bittencourt, D. Dermeval, S. Isotani, L. B. Marques and I. F. Silveira, 2018, *Brazilian Journal of Computers in Education*, 26, p. 33.

2.2.4. Research studies on Flow Theory.

In this section, examples of studies in the literature on Flow Theory will be given. First, examples from the literature from abroad will be given, then the studies conducted in Turkey will be presented.

2.2.4.1. Studies conducted abroad.

Chan & Ahern (1999) examined how content, presentation and the interaction of these two variables affect intrinsic motivation, in a learning activity in which Flow Theory was adapted. Accordingly, the findings indicated that the content of the activity affected motivation. In addition, the hypermedia presentation incorporated elements that motivate students when used only sparingly, often at the beginning of the lesson.

Egbert (2003) examined the relationship between experience of flow and language learning. The findings revealed that the foreign language classes provide flow experience. In addition, Flow Theory suggests an interesting and useful framework in order to conceptualize and evaluate language learning tasks.

Asakawa (2004) aimed to find answers to two major questions, by using ESM and collecting data from college students in Japan: First, whether the most fundamental principle of Flow Theory, that quality of experiences is a function of perceived opportunity and skill, were feasible to the Japanese sample. Additionally, how the perceptions of challenge and skill impact the quality of the experience of individuals with autotelic and non-autotelic characteristics, and how they balance the challenge and skill while dealing with routine affairs. According to the findings, the matches of high challenge and skills provided participants flow experience. In addition, it was determined that autotelic individuals were more successful than non-autotelic counterparts in providing the challenge-skill balancing.

Johnson (2004) aimed to examine the students studying in a school, which has a structure based on features such as a student-directed democracy, one-to-one relationship between learners and teachers, and learner-centered teaching, in the context of Flow Theory. The questionnaires, interviews and experience sampling method were conducted to gather data. The results indicated that learners in the spend more amount of time in learner-centered tasks and reflected higher levels of participation both in school overall and specifically while lecturing and studying independently. In addition, associations between autonomy, belongingness and student engagement were found positive and strong.

Armstrong (2008) investigated group flow in the same eight-grade mathematics classroom. In the study, videotapes and written transcripts were used in order to carry out analyses of studying procedures of the groups using Sawyer's pre-existing structures required for the presence of group flow, and Davis and Simmt's conditions for complex systems. According to results, although both groups have precondition structures for experiencing group flow, one of the groups could not be decentralized enough to allow all members to establish a collaborative proximal zone of development where they can collectively develop their ideas, but the other group could be decentralized enough which seemed to show the elements of entering the group flow.

Engeser and Rheinberg (2008) investigated whether the flow experience really depends on a balance between skill and challenge. They conducted three different studies to test this assumption. The results revealed that this assumption was partially supported, and moderated by the importance of the activity and by the achievement motive of the subjects. Additionally, in two of the three studies, performance variable was predicted by flow.

Cooper (2009) aimed to investigate the use of virtual worlds as learning environments in order to create revealing tasks and to better determine how the virtual worlds and user achievement and performance in educational settings are related, by examining in terms of Flow Theory. In the research, a web-based teaching framework was used. The results demonstrated that individuals' engagement and success were not positively correlated, but level of engagement and performance showed a positive correlation. Examining flow elements, engagement elements of control and distortion of time most significantly contribute to the performance. In addition, confirmatory factor analysis revealed that the flow elements clear goals and feedback loaded the highest, which offers a offering powerful relationships between the two factors.

Admiraal et al. (2011) conducted research to determine how flow concept affects student participation in the game-based learning process, game performance and learning. 216 secondary education students (average age thirteen) in Amsterdam played a game about medieval Amsterdam. According to the results, flow has effects on participants' performance, but not on their learning outcome. Distracting events and engaging in competitive situations among teams were found to have an effect on students' learning outcomes: Students learned more when they were less distracted and participated more in group competitions.

In the doctoral dissertation, Bourgeois (2012) aimed to examine the academic motivation of pupils who learn in private school settings in Germany and the United States. The study was conducted through the lenses of Self-determination and Flow Theories. The researcher investigated how extrinsic motivation affects intrinsic motivation, through the above mentioned two theories. Qualitative data were collected from academically gifted learners. The results have revealed that the teaching in the

the United States school provided greater learner autonomy and the feeling of belonging in the school setting, and more frequent flow state than their German counterparts. However, the instruction in German school more intrinsic interest and less competitive focusing in academic tasks than the American students.

Chang, Wu, Weng and Sung (2012) examined how asking problem activities affects elementary students' flow experiences and problem solving abilities. The results of the research showed that the students in the group who took the problem-posing activity had more flow experience and higher problem-solving ability.

Kiili et al. (2012) investigated the effects of using RealGame, which is a business simulation game, in an educational environment attended by university students, within the framework of Flow Theory. According to the results, university students experienced a high level of flow during the game process. Additionally, high scores were obtained in the autotelic experience and feedback dimensions while the dimensions with the highest scores were learner autonomy, clear goals, and the balance between challenge and skills.

Joo, Lim, Han, Ham and Kang (2013) investigated whether learner control, competence, and being relatedness predict learning flow, persistence and achievement in a blended learning environment. It was determined that learner control, competence and relatedness significantly predicted the learning flow in online and offline activities applied to a Chinese language learning course in which 102 adults voluntarily participated. In addition, it was revealed that competence, relatedness and learning flow significantly predicted success.

Kirchhoff (2013) investigated whether the Japanese students experience flow in an English reading class, what the flow conditions are, and whether the flow state affects the time and motivation for reading. The results indicated that students often experienced the flow condition during reading activities, but there was no correlation between experiencing more flow state and the time spent on reading.

Esteban-Millat et al. (2014) aimed to establish the role of flow experience in the behavioral processes of individuals in virtual learning environments. For this purpose,

they used the flow model in an e-learning environment and examined the effects. According to the results, altered perception of time and focused attention emerged as the most obvious direct antecedents of the flow state. The challenge of the learning environment, on the other hand, emerged as the main indirect requirement for the flow experience. In addition, it has been determined that flow state is effective in achieving positive affect (i.e. happiness, satisfaction and cheeriness) and student learning.

Sillaots (2014) conducted a study with students of master and bachelor level, in order to find out whether gamification could provide learners more appealing in the study of research methods, and using the game principles help students experience flow state. The results revealed that flow was experienced extensively, and most of the participants enjoyed engaging the game-like courses.

Aremu and Adebago (2016) examined how game flow experience and using games affect the mathematics scores of students in Nigeria. The findings demonstrated that the students who learned through game-flow achieved higher mathematics achievement than other group.

Hamari et al. (2016) examined the effect of flow elements such as challenge, skill, engagement and immersion on learning in educational game environments. The results of the research indicated that both engagement and challenge had positive effects on learning, while skill and challenge level positively affected engagement and immersion.

Gardiner (2017) investigated whether there is a link between student engagement and creativity and how creativity can be taught and supported in the classroom within the framework of Flow Theory. The researcher asserted that the engagement of the students could be better ensured by increasing their knowledge and skills in their creativity processes and playwriting expertise.

Dos Santos et al. (2018) conducted a study to determine how the flow state of the students was measured during the learning activities. They reviewed the literature to establish the experimental findings of the use of flow state in computer assisted learning activities on students' performance. According to the results of the study, 22

of the 25 studies that made experimental evaluations reported that computerized instruction, in which the Flow Theory was applied, provided positive results such as increasing students' learning and greater in-depth reflective process, generating pupils' satisfaction, and enabling exploratory behavior.

Tan and Sin (2021) conducted a literature review of studies on Flow Theory in music contexts. They reported that most of the research on flow gathered data through self-report questionnaires, interviews and observations. The results indicated that group experience of flow, the relation of flow and several positive outcomes, the reasons for flow state are some of the topics investigated in studies related to flow literature.

2.2.4.2. Studies conducted in Turkey.

Alperer (2005) investigated how the choices offered to the students affect their affective engagement. The researcher compared the types of choices for the tasks in English course that generated by students, assigned by teacher and no-choice. The participants were 26 university students who attend an English learning course at a state university in Ankara. According to the results, interactional structure of collaborative study provided significantly more positive results than activities in which students study individually and with whole-class. Moreover, the results also revealed that studying with interaction significantly affected the elements of flow including autonomy, task appeal and focused attention, but choice significantly affected autonomy and the attractiveness of the tasks. It was also revealed that the proficiency in the course and gender of students were not significantly related to affective engagement in the course.

Aydın (2005), in her dissertation, examined the effect of the stress coping program prepared based on Flow Theory on the stress coping strategies of 14–17-year-old adolescents. The researcher conducted an experimental study with pretest-posttest control group design. The results indicated that the scores of the experimental group on the strategies of general coping with stress, struggle, personal control, and effective contact with the environment increased significantly depending on the program applied compared to the control group. Based on these results, it was concluded that

the Coping With Stress Group Program based on Flow Theory is an effective program that can be applied to similar groups.

Inal and Çağıltay (2007) examined the flow state of 33 pupils aged from 7 to 9 in a game environment. The researchers collected data through interviews and observations. The results showed that being challenging and complex of the game affected more the flow state of subjects than feedback element. Additionally, boys had more flow experiences compared to girls.

Ak Şentürk (2010) aimed to reveal the level of flow occurred in several types of tasks in an English speaking course and to examine teachers' and learners' views whether they had a flow state during the speaking courses. 163 university students and eight teachers were the participants of this study. Scales, short questionnaires and interviews were used in order to collect data. The results revealed that flow presents in English speaking classes, but significant differences were found among the tasks. For example, the tasks related to classroom discussion provided more flow experience than other activities. In addition, the results showed that learners were more likely to have flow state, when the four elements of flow (autonomy, appealing tasks, concentration and challenges) were included in the activities. Finally, significantly better results were found in terms of flow experience in the classes where an interactive group study was conducted.

Kalay (2013) aimed to find out the effects of rhythm-based music education on flow state, achievement, and attitudes of learners in music course. The study was conducted with 55 third graders, through pretest posttest control group design. The results obtained from quantitative data indicated that there was no significant difference between the flow experience and attitude of experimental and control groups. The results obtained from diaries of both students and teachers showed that the total frequency of the expressions showing that students in both groups experienced flow are very close to each other.

Baydaş, Karakuş, Topu, Yılmaz, Öztürk and Göktaş (2015) conducted research with undergraduate students to find out the effect of guidance and experience on the retention and flow experiences, in a 3D virtual-world instruction environment. The

results indicated that there was significant difference between the retention scores, in terms of both guidance of the instructor and experience of the students, and the interaction of them. In addition, that there was a significant relationship between the flow and retention of all pupils, except those in the guided group.

2.3. Realistic Mathematics Education (RME)

The questions like how mathematics can be taught best, how we can enhance the interest towards mathematics and how students learn mathematics in reality have pushed the researchers to focus on those issues. The answers for such questions revealed that knowledge cannot be taken passively, on the contrary, knowledge is formed through the learners' own activities and effort (Nelissen, 1999). Mathematics instruction need to be actualized in a learning environment in which pupils actively engage in the tasks, learning mathematics is pleasurable for the learners, and students have positive attitudes towards mathematics (Uca & Saracaloğlu, 2017). At that point, RME has been one of the most affective learning theories which increases the students' attention towards learning mathematics and helps them to learn mathematical concepts and generalizations meaningfully, since it suggests beginning with the real-life situations and develops formal mathematical knowledge from students' own informal knowledge (Treffers, 1991). RME is a domain-specific mathematics teaching approach that emerged in Netherland in 1960s and 1970s, developed by Dutch mathematician and educator Hans Freudenthal and his colleagues (cited in Aydın Ünal, 2008). RME has been successfully used in mathematics education in the Netherlands for over thirty years (Olkun & Toluk-Uçar, 2014). This approach has been widely used by many countries around the world (Arseven, 2010).

Mathematics should be in relation with the reality, society and it should be close to the child. In RME, students learn mathematics through using and developing mathematics concepts and tools in daily life problems (contextual problems) or experiences (Heuvel-Panhuizen, 2003). It is aimed that children will be able to construct their own knowledge, share it with others and use these strategies in other similar situations (Wubbels, Korthagen, & Broekman, 1997). According to RME, mathematics began with the real-life problems in history, then the real life was regulated in terms of

mathematics and human being reached formal mathematics knowledge (Altun, 2008). Therefore, Freudenthal (2002) criticizes the traditional mathematics education since it handles the last products of mathematics as the starting point for mathematics instruction. That is, students should be taught mathematics beginning from the first problem, not the formulas, rules or other final statements.

2.3.1. Mathematization in RME.

Freudenthal (1983) objects to the idea that mathematics is abstract and formal school knowledge. He advocates that student should be given the chance to reinvent the mathematics by observing concrete events around us. Therefore, the instruction should be placed on facts that are acquaintance for the learners (such as diagrams, models, number line and classification techniques). The founders of RME and other researchers named the process of beginning real-life problems and constructing mathematical knowledge/concepts as *mathematization* (Altun & Yılmaz, 2008). Mathematization is the key process of RME due to two reasons (Freudenthal, 1971). First, mathematization is not for the job of only mathematicians, it is the job of every human being as well. When mathematization becomes a strategy for students, they will also look at other situations they face in daily life with a mathematical approach (Altun, 2008). The second reason is about the idea of reinvention. Formal mathematical knowledge (definitions, formulas etc.) is reached last, thus in teaching mathematics this sorting should be preferred (Freudenthal, 1971). Treffers (1987) expresses the concept of mathematization as horizontal and vertical types, which are explained in the following parts.

- 1. *Horizontal mathematization.*** Horizontal mathematization consists of schematization, formulation or visualization of a problem in different ways. In other words, it is the transition from the world of life to the world of symbols by transforming the real-life problems into a mathematical problem, exploring the relations and rules in several problems.
- 2. *Vertical mathematization.*** Vertical mathematization consists of reorganizing mathematical systems, the movements within the world of mathematical symbols. For instance, reinstalling relations in a formula, proving, using different models in

mathematics systems, integrating the different models, generalizing, and formulating an existing mathematical model are the vertical mathematization activities (De Lange, 1987).

These two mathematization stages are defined by Gravemeijer (1994) as the reinvention process and represented. Accordingly, in horizontal mathematization, the student starts with real life problems and then tries to explain the problems by making use of their own language and symbols. Formulating or visualizing a problem in different ways, discovering relationships are the processes of turning the real-life problem into a mathematical problem. In this process, it is possible for each student to discover a different solution. Vertical mathematization, however, is the achievement of higher-level mathematics by studying on symbols and reaching formulas by establishing relationships between concepts (Altun, 2006). This process again starts with real life problems, but in the long term, students may create certain rules which could be directly applied to other problems, and they do not necessarily need to connect with real life to do this (Akyüz, 2010).

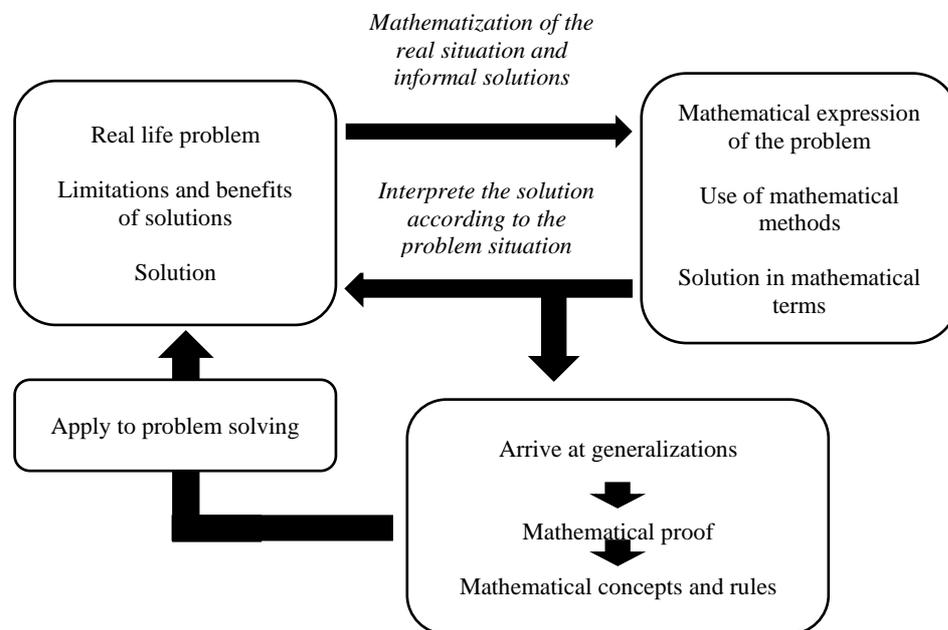


Figure 2.8. Learning Cycle According to Realistic Mathematics Education. Adapted from “İlköğretimde Etkinlik Temelli Matematik Öğretimi” (6th ed., p. 21), by S. Olkun and Z. Toluk Uçar, 2014, Ankara: Eğiten Kitap.

Accordingly, in horizontal mathematization, the student asks for an answer to the given problem situation and transforms it into mathematical language. After the problem situation is transformed into mathematical language, the student starts to produce solutions using mathematical methods related to this mathematical model in vertical mathematization. This latter process is carried out in mathematics itself. In this process, while the child learns new mathematical concepts and rules, he applies the newly learned mathematical knowledge to different problem situations.

De Lange (1996) clarified the process steps, which he defined as conceptual mathematics. Accordingly, it is very important that real contexts take place in the first step of learning mathematics. Hence, what is needed in teaching maths could be taking the real-world concepts, mathematizing, and returning them to use in the real life. These mathematization methods can be observed in different approaches used in mathematics education, but RME differentiates itself from other approaches. According to Treffers (1987), mathematics education is divided into four types in terms of mathematization criterion, which is demonstrated in Table 2.1 below.

Table 2.1

Types of Mathematics Education

	Horizontal Mathematization	Vertical Mathematization
Traditional	-	-
Empiricist	+	-
Constructivist	-	+
Realistic	+	+

According to traditional approach, mathematics is a discipline made up of rules and formulas. These rules and formulas are taught to students directly, and students simply memorize them without knowing what they are or will be used for in real life. Student activities in this approach are based on an algorithm or a simple memorization. If

students encounter a problem situation other than what they have memorized, they hesitate and make mistakes. Horizontal and vertical mathematics are not present in this approach.

In the empiricist approach, students learn from the environment they live in. Therefore, there is an informal situation that students have to solve. However, students are not encouraged to express this informal situation with a formula or model and to make generalizations. Therefore, only horizontal mathematization is used in this approach (Arseven, 2010).

In the constructivist approach, games and various activities used in horizontal mathematization are included. However, these games and activities are created from imaginary situations that have no place in the real life of the learner. Therefore, only vertical mathematization is used in this approach (Akyüz, 2010).

In the realistic approach, the starting point for learning is a real-world situation or life problem (Arseven, 2010). Students define and organize the problem with horizontal mathematics, express the relation of the problem with mathematics, then notice the relationships in this process. Then they develop mathematical concepts using vertical mathematization. Consequently, both types of mathematics can be used together in this realistic approach (Akyüz, 2010; Kurt, 2015; Özkaya, 2016).

2.3.2. Instructional design principles in RME.

When the literature is investigated, it is seen that principles of Realistic Mathematics Education were categorized in various ways. In RME, there are three important elements in order to design an instruction: *Guided reinvention, didactical phenomenology, and emergent modeling* (Freudenthal, 1991).

2.3.2.1. Guided reinvention through progressive mathematizing.

This principle indicates that learners should be provided opportunities to try the method or work that is similar with the invention of mathematics, since the real-world problems was explored intuitively in historical process, through the mathematization of that problems (De Lange, 1987; Freudenthal, 200; Gravemeijer, 1994). In addition,

the learning activity should have well-structured contextual problems in order to provide progress in learning mathematical concepts (Altun, 2008). The informal knowledge and strategies of the learners could serve to reach more formal knowledge and results. The problems are defined in a way that allows students to deal with them. As the learners construct meaningful knowledge to problems own their own, it becomes easier to make sense of and interpret the solutions (Gravemeijer, 1994). Students share their informal methods with their friends. During the sharing phase, a discussion environment should be created in the classroom, conclusions should be drawn from these discussions, and generalizations should be made. The accuracy of the results and generalizations should be questioned by the class. Thus, they develop more abstract mathematical methods (Olkun & Toluk Uçar, 2014).

2.3.2.2. Didactical phenomenology.

In didactical phenomenology, it is important that whether the topics and applications that are designed to be taught are suitable for mathematization. The job of mathematics teacher is to find appropriate real-world problems for the horizontal mathematization, and then to create learning environments that will provide vertical mathematization (Altun, 2008; Erbaş, et al, 2014). However, some educators may misunderstand this *real or realistic problem* concepts if they interpret it as referring to a really real objects or situations in the environment. That is, the word *realistic* not only refers to the relation with the real world, but also includes problem situations in pupils' minds (Heuvel-Panhuizen, 2000).

This principle provides to determine the map of daily life structures and the mathematical structures of an issue (Oldham, Valk, Broekman, & Berenson, 1999). In other words, real world problems serve as stimulant and help the pupils to learn the concepts through guided reinvention (Altun, 2008). Instead of searching for materials to concretize the concepts, the teacher should look for the phenomenon that can create mathematization opportunities. For example, for the addition of 5 and 3, if we ask the question “how many apples does it make 5 apples and 3 apples?”, then we explicitly state that this question necessitates an addition operation. However, if we ask the question like “I have 5 apples, my friend has 3 more than mine, then how many apples

does he have?”, this problem has more mathematical stimulation and the addition operation will be felt as a requirement (Üzel, 2007, p. 5).

2.3.2.3. Emergent modeling.

According to this principle, the designer of the instruction should create problem situations that can serve to discover abstract and formal mathematical concepts. Rather than using modeling activities alone as a practice problem in different parts of the course, this approach emphasizes designing appropriate learning environments selected from real-life situations and presenting them to students' experiences (Erbaş et al., 2014). When they meet a new problem, students may develop a model that is familiar to them. However, the model gradually will gain independence, after generalizing and formalizing processes (Erbaş et al., 2014). This process is labeled as a transition from *model-of* to *model-for*. After the transition, the model may be used as a model for mathematical reasoning. The main purpose of using the models should not be explaining the mathematics from an expert's perspective, on the contrary, models should support students in creating mathematical concepts starting from their point of view (Gravemeijer, 1994).

2.3.3. Basic characteristics of RME.

With the combination of Freudenthal's (2002) didactic phenomenology and progressive mathematics of Treffers (1987), the following 5 features of RME emerge. These features can be summarized as follows:

2.3.3.1. The use of real-life contexts.

Real life problems in RME are designed to support the re-discovery process that allows students to reach formal mathematical knowledge. Real life problems play a central role in RME because of their motivating power and the opportunity for students to see the usefulness of what they have learned (Gravemeijer & Doorman, 1999). Thus, the instruction should consist of phenomenological exploration (Gravemeijer, 1994). According to RME approach, the starting point of an instruction is providing situations which can be experienced and taken part in meaningful mathematical activities by the students. The starting point should be perceived as if it is real by the pupils (Olkun &

Toluk Uçar, 2014). Real world problems are used to support reinvention process which helps students reach formal mathematics knowledge. Such problems play a central role in RME, because of the opportunity to see the usefulness of the students' learning and their motivational power. In traditional approach, problem solving is applied at the last stage of the instruction in order to apply theoretical knowledge (Gravemeijer & Doorman, 1999).

2.3.3.2. The use of models.

The process of mathematization includes the use of models such as schemas, tables, drawings etc. Searching for proper models and working on them is the first step for formal mathematics and abstraction. Through models, students can learn using abridgments and schematizations which provide high level formalizations (Nelissen 1999). Similarly, Gravemeijer (1994) supports the idea that visual models, model cases and schemas that arise from problem solving activities can help students to make transitions among different stages.

2.3.3.3. Student's free production.

In this principle, students are expected to produce more concrete things. For example, they might write an article, do an experiment, collect data or develop a test for their classmates (De Lange, 1995). During mathematics instruction, students should be given chance to develop their own informal problem solving strategies and increase their self-confidence (Widjaja & Heck, 2003). Even with the guidance of a teacher, it is essentially the students themselves who make up the lessons. Free productions in class help teachers to determine the development and creative thinking skills of students (Treffers, 1987).

2.3.3.4. Interaction.

In RME, the interactions among learners and between learners and teacher are very important, since students have the opportunity to express their ideas and learn from peers' opinions. Students explain, summarize, share and advocate ideas, ask questions and reflect their thoughts (Treffers, 1991). However, RME is not against to giving opportunity to work individually, in order to help pupils to find idiosyncratic solutions

and to do better mathematics (Cansız, 2015). The aim of this principle is to draw attention that whole class activities play important role on doing mathematics. However, it does not mean that all the students in the class move in simultaneously and that every student in the class can reach the same level of development. On the contrary, in RME, each of the students is considered as a separate individual, taking individual differences into account. This is only possible with the presentation of problems that students can solve at different levels of thinking (Heuvel-Panhuizen & Wijers, 2005)

2.3.3.5. Intertwining.

Mathematics is one of the subjects whose topics or stages are interconnected and cumulative. Therefore, a new topic or stage cannot be taught without the previous topics are learned. Freudenthal (1973) states that the related topics are learned much more quickly and are not slipped one's mind for a long time. This means that the rings that make up learning are processed together, not separately, but integrated into problem solving (Treffers, 1991).

2.3.4. The core teaching principles of RME.

Core principles have emerged in mathematics teaching as a result of the rearrangement and development of the above-mentioned characteristics (Heuvel-Panhuizen & Drijvers, 2014; Treffers, 1987). These principles are clarified briefly in the following paragraphs.

2.3.4.1. Activity.

This principle means the active participation of students while learning. It is advocated that individuals will learn mathematics best by doing mathematics, since mathematics is a human activity (Heuvel-Panhuizen & Drijvers, 2014).

2.3.4.2. Reality.

This principle in RME might be interpreted in two ways. The first is to start teaching mathematics by presenting real-life problems to learners in problem solving practices, and the second by presenting problem situations that enable them to make sense of the

mathematical structures they have created while solving problems, even if not from real-life (Heuvel-Panhuizen & Drijvers, 2014). Instead of starting mathematics teaching with certain abstractions or definitions, one should start with rich mathematical situations that will not be quick to forget (Uygur, 2012).

2.3.4.3. Level.

The meaning of learning mathematics is that students go through various levels of understanding ranging from informal solutions to the formal solution, modeling, symbolizing and shortening various stages to being able to distinguish higher level relationships (Erdoğan, 2018). Models act as a bridge between informal, contextual mathematics and formal mathematics (Heuvel-Panhuizen & Drijvers, 2014).

2.3.4.4. Intertwinement.

Since the objectives and topics in mathematics lesson progress in a compatible and cumulative way, it is impossible to learn the content domains independently. For example, while learning numbers learning area, subjects such as mental arithmetic, prediction and algorithms should also be taught in conjunction (Heuvel-Panhuizen & Drijvers, 2014).

2.3.4.5. Interaction-Cooperation.

Learning mathematics is seen as a social activity in RME. By seeing what other students have found and discussing on them, students get ideas to improve their strategies. In addition, interaction (cooperation) leads to the birth of ideas that will enable students to understand at higher levels (Demirdöğen, 2007). RME supports opportunities for students to share learning strategies and solutions to problems with their classmates (Heuvel-Panhuizen & Drijvers, 2014).

2.3.4.6. Guidance.

Guidance principle refers to Freudenthal's *guided reinvention* of mathematics (Heuvel-Panhuizen & Drijvers, 2014). In Realistic Mathematics Education approach, curriculum and teachers should be able to direct the learning process, but not limit it. In order for students to create their own interpretations and products, teachers should

organize learning environments where they will enable students to structure the concept. While organizing these learning environments, the teacher should be able to predict how and where the students will react (Uça, 2014).

2.3.5. Instructional design in accordance with RME.

Streefland (1991) emphasizes that according to RME the following three levels should be considered in developing mathematics lessons: The local or classroom level, the global or course level, and the theoretical level. These levels are explained briefly in the following paragraphs. At the *local/classroom level*, courses are designed considering all the features of RME and the focus is on horizontal mathematization (Zulkardi, 2010). First, a material suitable for the learning situation is presented, and opportunities for free production are provided. This prepared material should enable students to produce mathematical knowledge and be supported by their existing knowledge (Akyüz, 2010). Opportunities are provided for students to produce tools such as symbols, diagrams, and models of situations or contexts through group work that they can learn socially. A learning environment is prepared for the students to participate actively and to support them to discuss, collaborate and give and receive feedback. It is necessary to encourage learners to participate in similar activities by giving them tasks that allow them to produce original products (Zulkardi, 2010).

At the *global/course level*, materials structured at the classroom level are developed to contribute to the learning process at the general level (Akyüz, 2010). In other words, rather than using the same materials, students make similar applications by exploring their different dimensions. At the course level, as at the previous level, emphasis is placed on horizontal mathematization (Altner, 2021). However, at the *theoretical level*, it is aimed to provide a transition to an abstract environment, starting from a physical model that can be encountered in real life. Therefore, while the previous two levels are working on horizontal mathematization, there is a focus on vertical mathematization at this level (Üzel, 2007). Everything that existed at previous levels, such as all group studies and activities, educational discussions, classroom practices, is also useful material for this level (Arseven, 2010).

2.3.6. Preparing a lesson plan according to RME.

According to Zulkardi (2010), in order for a lesson to be prepared in accordance with RME, the parts of the lesson plan (objectives, content, methodology and assessment) must be designed in accordance with the principles of RME. To put it more clearly, it is advocated that every student will be able to reinvent mathematics if steps such as (1) selecting materials suitable for the outcomes, (2) determining different learning techniques, (3) determining the relationships between learning paths, (4) creating new materials under the guidance of the teacher, and (5) determining the extent to which critical behaviors have been succeeded at the end of the teaching are prepared in accordance with RME (Çilingir, 2015).

2.3.6.1. Goals.

De Lange (1995) defined three levels of goals in mathematics education: Low, middle and higher level goals. In lessons designed according to the traditional program, the goal levels are less clear. These lessons include low level goals related to formulas, simple algorithms and definitions. However, in RME based lessons, the goals are generally middle or higher level. At middle level, students are expected to have skills such as linking different tools of the lower level and integrating concepts. At higher level goals, students are expected to achieve reasoning, thinking, communication skills and critical behaviors.

2.3.6.2. Content (Materials).

RME materials consist of domain-specific, generally known, real-life situations or strategies. While preparing materials for RME, problem situations with various solutions should be included (De Lange, 1996).

2.3.6.3. Methodology (Activities).

In a lesson based on RME, students are expected not to seek directions or answers to suggest a standard solution to problems, but to be able to produce and contribute freely through studying together, and as a result, to increase their self-efficacy (Zulkardi,

2010). The teacher's role, on the other hand, was determined as being a facilitator, an organizer, a guide and evaluator (de Lange, 1996).

2.3.6.4. Assessment.

The assessment procedure in RME aims to improve students' learning. Therefore, the assessment should be conducted during an ongoing activity or right after the course. The assessment result should indicate what students know, rather than what they do not know. The tools used for assessment should be practical, suitable for the school environment and obtainable to external resources (de Lange, 1996).

2.3.7. Comparing RME with traditional approach and Constructivism.

The main difference between the traditional approach and RME is the starting point. While the traditional approach is based on abstract principles and rules to learn a concrete application, this is not the case in RME (Wubbels et al. 1997). While explaining the process of obtaining mathematical knowledge in RME, it is followed by dealing with real-life problems first, then noticing generalizations, using notations, and finally returning to practical problems and obtaining the algorithms of solution procedures. In this approach, a formal system is reached in practice. In this respect, the teaching that the traditional system offered, firstly teaching the formal system and then making applications, was seen as anti-didactic by the RME approach (Bintaş, Altun & Arslan, 2003). RME provides students with opportunities to learn mathematics through activities they experience in daily life. Thus, RME facilitates students' learning by enabling them to rediscover mathematical concepts and build knowledge themselves (Fauzan, 2002). In this respect, it is possible to say that RME is more similar to the principles of the constructivist approach, although there are differences between them. In the constructivist approach, the curriculum begins with a philosophy that gives students the freedom to construct or reconstruct their own structures (Arseven, 2010). The constructivist approach has four basic epistemological principles. These principles are given as follows:

1. The information is not received passively by the individual, on the contrary, it is formed as a result of a cognitive action performed by the individual under his/her control.
2. Learning (acquiring knowledge) is an adaptation process.
3. Learning is subjective, non-objective, that is, everyone learns in their own unique way.
4. Learning is a process influenced by social interaction, culture and language (Cited by Üzel, 2007 from Doolittle, 1999).

Constructivist learning is basically a theory of knowledge, rather than a teaching theory, and it is about how we acquire knowledge. However, RME is an instructional theory. Despite this difference in basics, the implications for mathematics education have strong similarities (Altun, 2006). In other words, RME approach accepts the learning principles of constructivism, but unlike constructivism, it is a more specific approach to teaching mathematics (Yağcı & Arseven, 2010). The most distinctive feature of constructivist learning is that students care about the difference in interpretation of external representations and, accordingly, the difference that occurs in internal representations. The task of the teacher in teaching is to prepare the necessary conditions for students to form their own knowledge (Altun, 2006). The difference between constructivist learning and RME arises in the steps followed in structuring the knowledge. While RME opposes teaching theoretical knowledge and practice separately, constructivist learning does not deny this. In fact, constructivism accepts any learning style that is based on informal knowledge and experiences and allows students to create knowledge (whether theoretical or practical) (Gravemeijer et al., 1990).

According to the review of the literature, three types of constructivism are mentioned in mathematics education (Zulkardi, 2010): Cognitive Constructivism, Social Constructivism, and Radical Constructivism. To summarize these briefly;

Cognitive Constructivism: Cognitive constructivism is the constructivist approach that first emerged in the field of education and is widely used in various teaching fields.

This approach gives importance to individuality, cognitive processes, internal structure and experiences in the construction of knowledge and the formation of learning, based on Piaget's views (Eggen & Kauchak, 2010). Cognitive constructivists who find social interaction valuable in terms of acting as a catalyst for individuals to experience cognitive conflict have been criticized for neglecting social interaction in learning (Palincsar, 1998). According to this approach, learning is based on exploration, experience, and the individual's propensity to adapt to their environment. In this way, the individual tries to balance between the schemas he has and the environment he interacts with (Simina, 2012).

Social Constructivism: Social constructivism lies between cognitive constructivism and radical constructivism (Üzel, 2007). According to this approach, which is based on Vygotsky's (1978) work, social interaction, culture and language have an important place in the formation of knowledge. This approach helps to resolve the dilemma about teacher roles by challenging the notion that teachers step aside and expect students to continue their natural work as the Piagetian view advocates. Accordingly, teachers should be involved in the process by taking into account all conventional questions such as how to organize and conduct the learning activity, motivate learners and evaluate learning (as cited in Eggen & Kauchak, 2010, p. 45). Moreover, the concept of the *zone of proximal development* is fundamental in the social constructivism approach, because during the scaffolding process the student is supported in such a way that she can perform beyond the maximum level that she can demonstrate herself (Simina, 2012). Social constructivism takes care of all four epistemological principles mentioned above. These four basic principles emphasize the characteristics of knowledge that protect its social nature, and that knowledge emerges as a result of social interaction and the use of language (Üzel, 2007).

Radical Constructivism: Radical constructivism is a view that emerged as a result of the reinterpretation of social constructivism, and it is also heavily indebted to cognitive constructivism, particularly Piaget's views (Aktürk-Muğaloğlu, 2001). According to this approach, acquiring knowledge is an adapted process that results in active learning by the learner. Radical constructivism argues that knowledge about reality emerges depending on individuals' own experiences, cognitive capacities and interactions with

the environment. Since the environments in which individuals interact and their level of comprehension are different, each individual's knowledge of reality also varies (Altun, 2006). Radical constructivism suggests that problem solving can be used in mathematics teaching, that students should interact with other learners and teachers, and that students should be given opportunities to use their own strategies. Additionally, radical constructivism fully embraces the first three of the four basic epistemological principles mentioned above (Üzel, 2007). The meaning that radical constructivist theory ascribes to the importance of social interaction in learning is different from that of social constructivist theory. Social interaction and working with groups are important in radical constructivism as it enables the student to reflect on the concepts (Altun, 2006).

The environment in constructivist learning is important for the teaching of mathematics, but not as essential as it is in RME. Constructivist learning takes place as long as the teacher plans the problem situation and the content of the subject based on the students' prior knowledge and experiences (Gravemeijer et al., 1990). In addition, accessing information in RME is different from the hierarchy in Bloom's Taxonomy. As seen in Figure 2.9 below, since RME starts with daily life problems in line with the stimulation from the environment, it first occurs in the form of descending from the application level to lower levels and then to higher levels (Altun, 2006). Horizontal mathematization takes place when descending from the application level to the lower levels, and vertical mathematization occurs when ascending to higher levels (Üzel, 2007).

According to de Lange (1996) the features of radical constructivism comply with the guidelines prescribed by RME. One of the similar features of RME and radical constructivism is that both have been created independently of constructivism. Secondly, in both approaches, students are suggested to share their experiences with their classmates (Zulkardi, 2010). However, radical constructivism does not recommend horizontal mathematization as suggested by the RME, especially when preparing learning activities for students (Üzel, 2007).

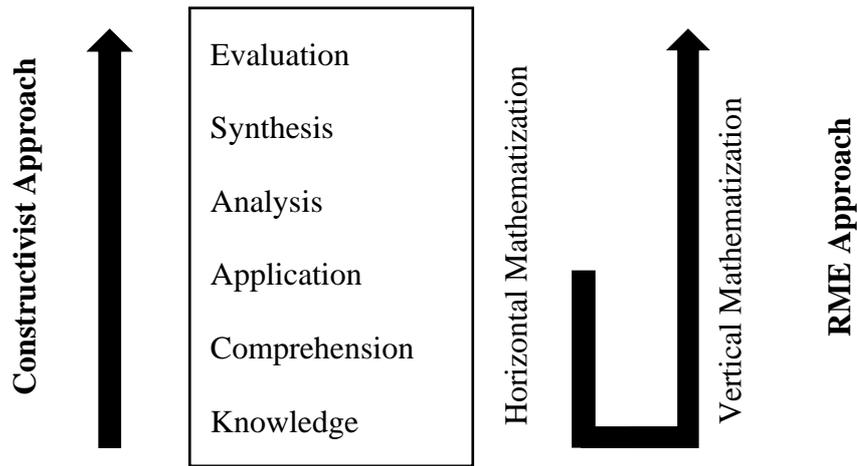


Figure 2.9. Comparison of the stages in constructivism and RME. Adapted from “Matematik Öğretiminde Gelişmeler”, by M. Altun, 2006, *Journal of Faculty of Education*, 19, p. 231.

The type of material to be selected in creating the learning environment in RME is determined according to the interests and needs of the student. According to RME, it is emphasized that if some basic functions are fulfilled, every student can invent mathematics. These functions include that searching for suitable models for teaching, finding learning ways to foster the concept formation process, examining the relationships between different learning paths, developing materials with the help of teachers, and trying different alternatives in mathematics education. With these features, RME is closer to social constructivism. However, mathematization in RME can be described as an advanced level of the signification process in social constructivist theory (Altun, 2006).

2.3.8. Research studies about RME.

In this section, examples of studies in the literature on RME were presented.

Fauzan (2002) determined the general characteristics of instruction designed based on RME and investigated the effect of such instruction on students’ achievement, motivation. The results have shown that the motivation scores of the experimental group significantly increased after the treatment, compared to control group.

Additionally, the results also indicated that the individuals who experienced the RME based teaching had significantly higher achievement scores than pretests.

Arseven (2010) examined the effect of RME-based learning activities on learners' achievement, problem solving skill and attitude towards mathematics. The researcher conducted a mixed method design and gathered both quantitative and qualitative data types. The results indicated that the instruction applied in experimental group was significantly more effective than the instruction in control group.

Altaylı (2012) investigated the effect of instruction designed based on RME on the mathematics achievement and proportional reasoning skills of elementary seventh grade students. The study was conducted through a quasi-experimental research design. The results indicated that experimental group students had greater achievement than control group.

Uça (2014) aimed to determine the interpretation process of fourth grade students during the activities developed based on RME approach. The study was conducted through a design research and data were collected through interviews, observations, video recordings. The results indicated that the individuals were able to advance in measurement of weigh activities, read decimals, relate the part and whole, etc.

Zakaria and Syamaun (2017) explored the effects of RME on 61 high-school students' achievement and attitudes towards mathematics. They conducted quasi-experimental research design. The results indicated that the attitudes of experimental and control group students did not significantly differ, but the achievement of the two differed significantly.

Altunay (2018) investigated the effect of mathematics instruction which include learning activities prepared based on RME approach on students' achievement and retention in mathematics. Third grade 53 students participated in the study and quasi-experimental research design was used. The results have revealed that the achievement of experimental group students have increased and this was retained in the follow-up tests, while the scores of control group on pretest, posttest and retention test did not differ significantly.

2.3.9. The harmony of Flow Theory and RME.

A lesson organized according to the RME enables children with different levels of skill and understanding to work on the same problem in the same classroom. In RME, students can share and discuss their strategies with their friends (Heuvel-Panhuizen, 2000). The general characteristics of learning environments which are conducive to flow show great similarities with the principles of RME. In other words, it can be possible that learners get into flow condition when learning mathematics, if the mathematics instruction holds RME attributes. For instance, Norman (1993) states that *providing high intensity of interaction and feedback* is one of the characteristics of flow activities. When students are provided immediate, constructive feedback, and encouraged working cooperatively they will be more likely to experience flow (Schweinle et al., 2006). Similarly, among the learners and teacher-learner interactions are seen as the fundamental principle in RME (Üzel, 2007). Through the interactions, students express their ideas or solutions for the problems, or they have the chance to fix their missing or wrong parts in their responses while they are listening to classmates' answers.

Another principle of Flow Theory claims that before the activity starts, it should have specific goals that meet the needs, in order to promote participants to live the flow experience. That is, the more obvious the goals are in the pupils' consciousness, the more likely it is that he/she experiences the flow situation (Jackson & Ecklund, 2004). Similarly, RME approach strictly proposes that educational curricula should include learning scenarios which are prepared compatible with the mathematics goals to be reached (Heuvel-Panhuizen & Wijers, 2005). Those scenarios should consist of well-prepared contextual problems that relate the mathematical concepts with learners' imaginary world (Altun, 2008).

RME-based instruction supports students to generate their own strategy while solving problems (Widjaja & Heck, 2003). Students are free to identify the methods or techniques necessary to solve the problem. In addition, they can use and create their own models during mathematization. This situation has shown parallelism with the principle of sense of potential control and autonomy, which provide more flow in a

learning environment or tasks (Abbott, 2000). As Hektner (1996) states that pupils who reported high levels of flow has more autonomy than pupils who reported lower levels of flow.

In RME, mathematics is taught through real-world situations or contextual problems that are familiar with the students' imaginary world and informal knowledge. Hence, mathematics instruction is more likely to become attractive for the learners. As a result, it is possible that students are disposed to attend mathematics courses. This supports the principles advocated by the Flow Theory. When an activity has the characteristics described above, the participants are more likely to lose self-conscious and feel that the time passes faster than normal (Jackson & Csikszentmihalyi, 1999).

2.3.10. Summary of the literature review.

In the literature review chapter, the detailed information was given about the studies on Flow Theory and Realistic Mathematics Education approach that form the basis of this study. In the literature, several studies state that the use of Flow Theory might be affective on decreasing negative emotions and thoughts by many people in schoolwork and especially learning mathematics. However, when we look at the relevant literature, it is noteworthy that Flow Theory is mostly applied in computer supported, web-based and technology-oriented activities based on computer games, game-based software, and their effects on affective states such as motivation, engagement, flow experience and cognitive skills such as achievement, game performance, problem solving skills etc. (Admiraal et al., 2011; Aremu & Adebago, 2016; Baydaş et al., 2015; Cooper, 2009; Esteban-Millat et al., 2014; Inal & Çağiltay, 2007; Kiili et al., 2012; Sillaots, 2014). In addition, when the studies in the literature are examined, it is seen that Flow Theory is used in various foreign language teaching courses (Ak Şentürk, 2010; Alperer, 2005; Egbert, 2003; Joo et al., 2013; Kirchhoff, 2013). In these studies, it was seen that the researchers investigated whether the methods and techniques used in foreign language teaching provide the learners with the level of flow experience, or comparisons are made between different teaching techniques in terms of providing flow experience.

In addition, in the literature, there are also studies which explored the effects and usage of Flow state in music education. For example, while Tan and Sis (2021) conducted a literature review examining the studies on Flow Theory in the context of music, Kalay (2013) conducted an experimental study examining the effects of rhythm-based music education on the flow state. In studies where Flow Theory is used in mathematics education, it is seen that the level of flow state experienced by students in group and game activities is examined. On the other hand, it can be said that experimental studies examining the effects of an instruction developed based on Flow Theory are very rare. Furthermore, studies consist of correlational ones that explain which of the dimensions or principles suggested by the Flow Theory are observed.

On the other hand, according to the literature, there are many experimental studies on RME, which is used in mathematics instructional design by integrating with Flow Theory. In these studies, the effects on academic achievement and several affective characteristics were examined by comparing the instruction designed according to RME with instruction carried out according to traditional or other approaches (Altaylı, 2012; Arseven, 2010; Fauzan, 2002; Zakaria & Syamaun, 2017).

CHAPTER III

METHOD

In this chapter, the methodology of the study was presented under the subtitles of research design, research questions, variables, subjects of the study, data collection instruments. In addition, the information about data collection procedure and analysis of data was explained in the following parts of the chapter.

3.1. Research Design

In this study, a pretest-posttest control group design was used, which is a type of quasi-experimental research design (Creswell, 2015). The reason for using a quasi-experimental design is that the study was carried out with subjects who were already in intact groups, since the random assignment of the subjects to experimental and control groups was not possible. The experimental design of the study is given in Table 3.1 below.

Table 3.1

The Experimental Design of the Study

Groups	Pretest	Experiment	Posttest*	Retention Test**
G ₁	M ₁	X	M ₂	M ₃
G ₂	M ₁		M ₂	M ₃

G₁ = Experimental Group G₂ = Control Group

X = Instruction designed according to Flow Theory Principles and RME

* Applied for MAT, FSS, and MMS,

** Applied only for MAT

According to Cohen, Manion & Morrison (2007), in cases where random assignment is not possible, checking whether groups are equivalent in terms of the characteristics to be examined can make the design stronger. In order to check the equality of the two groups, the data collection tools Mathematics Test (MT), Flow State Scale (FSS) and Mathematics Motivation Scale (MMS) were conducted as pretests, and the data were analyzed through independent samples *t*-tests (which is presented in the subjects of study part of this chapter). The overall research design of the study can be seen in Figure 3.1 below.

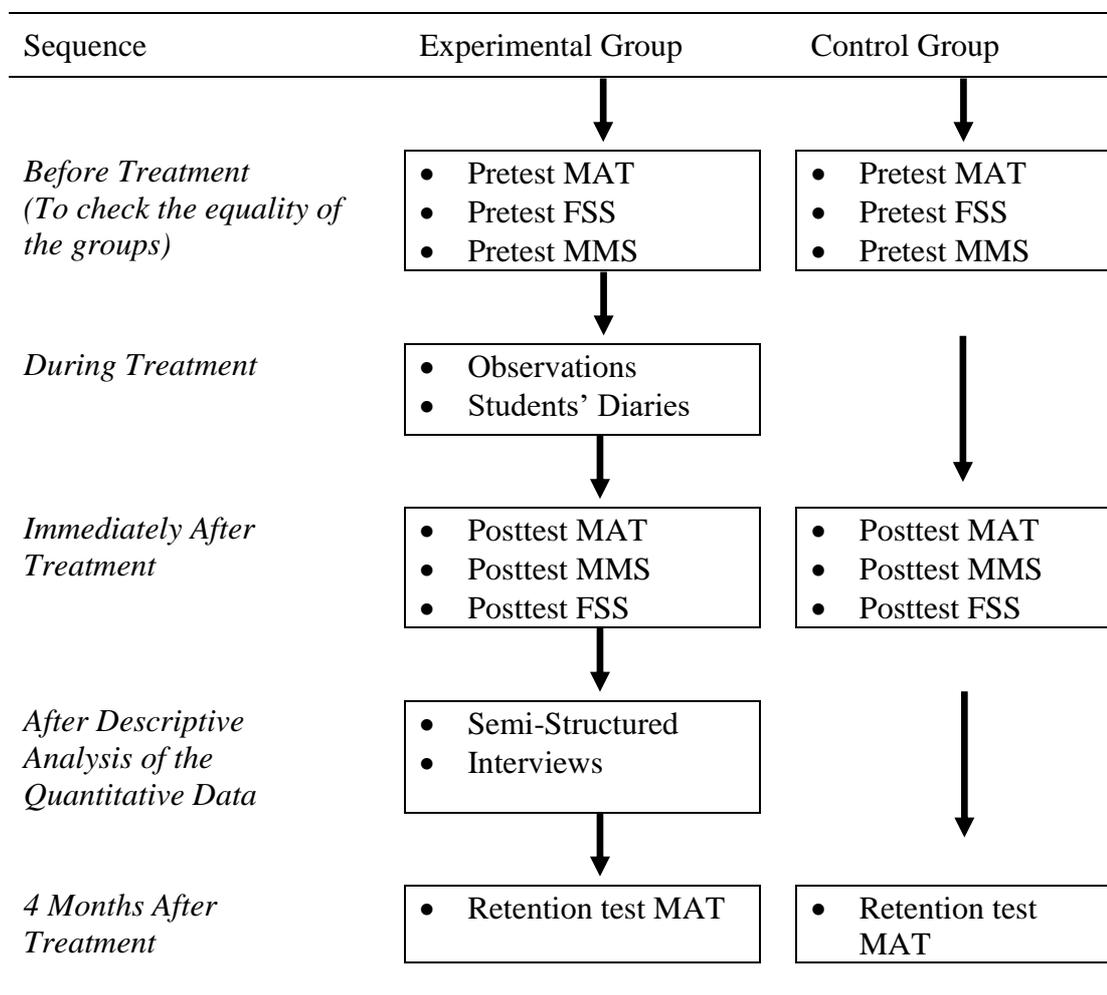


Figure 3.1. Overall research design of the study

In the study, quantitative data was supported with qualitative data in which it is aimed to determine the opinions of experimental group students about the instruction they experienced and how this teaching affected their thoughts, learning and feelings etc. For this purpose, semi-structured interviews and classroom observations were conducted. Additionally, experimental group students were asked to keep a diary at the end of each lesson. All qualitative data obtained were combined and analyzed, holistically.

3.2. Research Questions

The purpose of this study was to design and implement an instruction based on the principles of Flow Theory enhanced with RME, for the fifth-grade mathematics course, and to investigate the effects of this instruction on students' achievement, retention, flow state, and motivation. The following research questions were investigated in the study:

1. Is there any significant difference between the Mathematics Achievement and Retention scores of students in the experimental and control group?
2. Is there any significant difference between the Flow State scores of students in the experimental and control group?
 - a) Is there any significant difference between the Flow subdimension scores of students in the experimental and control group?
 - b) Is there any significant difference between the Boredom subdimension scores of students in the experimental and control group?
 - c) Is there any significant difference between the Anxiety subdimension scores of students in the experimental and control group?
3. Is there any significant difference between the Mathematics Motivation scores of students in the experimental and control group?
4. What are the opinions of experimental group students about the treatment?

3.3. Variables

The study consisted of five variables. One of them was independent and four of them were dependent variables. The independent variable was the treatment effect of the instruction designed based on Flow Theory principles and enhanced with RME approach; while students' achievement, retention, flow state and motivation were the dependent variables of the study. The independent variable was used as the treatment in the experimental group, while no intervention was made to the control group, and they received the instruction in accordance with the curriculum prepared by the Ministry of National Education (MoNE, 2017). Those variables were explained below:

Independent variable: Instruction applied in experimental group

Dependent Variables: Immediate mathematics achievement, mathematics retention, flow state (flow, boredom and anxiety subdimensions), and mathematics motivation.

3.4. Context

The study was conducted throughout the spring semester of the 2017-2018 academic year and lasted 11 weeks. The school where the study was conducted was a public school and located in a region with a middle-level socioeconomic status, in Bornova - İzmir. In each class at school, there were approximately 35 to 40 students.

As the researcher met with the students and the teacher frequently throughout the study, a school was chosen which was easily accessible, and the school administration would provide the necessary convenience and permissions for the study. In addition, the fact that the teacher who would implement the instruction was curious and eager to participate in the scientific studies, open to follow the innovations in teaching helped the researcher to decide to carry out the study in this school. The teacher graduated from department of elementary mathematics education, had three years of experience in teaching and was continuing graduate education in the field of mathematics education, and had the knowledge and practice to use technology effectively in the lessons.

The study was conducted in the fifth-grade mathematics course that aims to develop students' mathematical literacy skills, to enable them to understand mathematical concepts and to use these concepts in daily life, to improve their metacognitive knowledge and skills, and to develop a positive attitude towards mathematics (MoNE, 2017). Fifth grade mathematics curriculum approved by the MoNE consists of three learning areas: Numbers and Operations, Geometry and Measurement, Data Processing. According to the annual plan, the learning areas to be covered in the weeks of this study were Numbers and Operations, and Geometry and Measurement, which included 5 topics in total: 1. Percentages, 2. Basic Geometric Concepts and Drawings, 3. Triangles and Quadrilaterals, 4. Measurement of Length and Time, 5. Measurement of Area.

3.5. Subjects of the Study

The subjects of the study consist of students attending the fifth grade of a public school in Bornova – Izmir, in the 2017-2018 academic year. Totally 73 students participated in the study. The experimental group consisted of 37 students, while the control group consisted of 36 students.

Table 3.2

The Gender Distribution of Experimental and Control Groups

Group	Gender	<i>N</i>	%
Experimental Group	Female	14	37.8
	Male	23	62.2
	Total	37	100
Control Group	Female	16	44.4
	Male	20	65.6
	Total	36	100

As presented in Table 3.2, among the students of the experimental group, 14 (37.8 %) of them were female and 23 (62.2 %) of them were male. Among the students of the

control group, 16 (44.4 %) of them were female and 20 (65.6 %) of them were male. In order to determine the equivalence of the groups, measurement tools (MT, MMS and FSS) were applied to both classes as a pretest before the experimental procedure, and the obtained data were analyzed through the independent samples *t*-tests. After it was determined that the classes were equivalent, the groups were randomly assigned as experimental and control groups.

For the qualitative data of the study, the experimental group students were asked to write a diary about the mathematics lesson at the end of each week. In addition, students for semi-structured interviews were selected purposefully after conducting Mathematics Test as posttest, in order to learn their opinions about the instruction, effectiveness of it, and whether they would like the courses to continue with such instruction method, etc. For this purpose, maximum variation sampling method was conducted (Patton, 2014/2002). The codes and demographics of students selected for interviews can be seen in Table 3.3 below.

Table 3.3

The Codes and Achievement Levels of Interviewed Students

Gender	# of Correct Answers	Achievement Level	Code of Subject
F	8	Low Achiever	S1
F	9	Low Achiever	S2
M	9	Low Achiever	S7
F	10	Medium Achiever	S5
M	12	Medium Achiever	S8
M	14	Medium Achiever	S9
F	14	Medium Achiever	S10
M	16	High Achiever	S6
M	18	High Achiever	S3
M	18	High Achiever	S4

As seen in Table 3.3, based on the achievement scores in the posttest MT, 10 students (three high achievers, four medium achievers and three low achievers) were determined as interviewee students among 37 students of the experimental group, in order to ask their thoughts about the experimental process. The scores of the students in the posttest of MT were listed in descending order. The students with correct answers between 5 and 9 (since the minimum score on posttest was 5) were considered as low achievers, the students with correct answers between 10 and 14 were considered as medium achievers and the students with correct answers between 15 and 18 were considered as high achievers.

3.5.1. Determination of equivalence and characteristics of study groups.

Before the treatment, the researcher examined the equivalence of the two groups that would be assigned as experimental and control group. For this purpose, the data collection instruments MT, FSS and MMS were conducted to both groups as pretests (Creswell, 2015). The data obtained from the pretest of the instruments were analyzed through independent samples *t*-test, using SPSS 25 (IBM, 2019). The results of independent sample *t*-tests were presented in the following parts.

3.5.1.1. Comparison of pretest mathematics scores (PREMAT).

Before comparing the pretest scores, Skewness and Kurtosis values, histograms, Q-Q plots, and Kolmogorov-Smirnov and Shapiro Wilk Tests of the dependent variable (PREMAT) at each group (Experimental and Control) were explored to examine the validity of normality assumption (Field, 2013). Only Kolmogorov-Smirnov Test (K-S test) could not provide the normality assumption for both groups, while the Shapiro-Wilk Tests were found to be non-significant for both groups. In addition, the skewness and kurtosis values indicated that mathematics pretest scores were normally distributed, since the values were between -1 and +1 for both groups. Q-Q plots also showed the normality of distributions as the plots were around the line, and they were not scattered too much from the line. Moreover, visually the distributions were seen approximately normal from the histograms.

Homogeneity of variances assumption was tested using Levene's Test. According to the results of Levene's test, there was no statistically significant difference between the variances of experimental and control groups ($F = .231, p = .632$). As the assumptions were met, independent t -test analysis was conducted, and the results were presented in Table 3.4.

Table 3.4

t-Test Results Comparing the Groups on PREMAT

Variable	Groups	N	M	SD	Levene's Test		t	df	Sig.
					F	Sig.			
PREMAT	Experimental	37	39.34	15.292	.231	.632	.241	71	.810
	Control	36	38.43	17.027					

According to Table 3.4, independent samples t -test results revealed that there was no statistically significant difference between the mean scores of the experimental and control groups on mathematics pretest (PREMAT) scores, $t(71) = .241, p > .05$. That is, the mean score of experimental group on PREMAT ($M_E = 39.34, SD_E = 15.29$) was not significantly different from that of control group ($M_C = 38.43, SD_C = 17.03$).

3.5.1.2. Comparison of pretest Flow State Scale scores (PREFSS).

Since the total score of the Flow State Scale was not suitable, the scores of subdimensions (namely Flow, Boredom and Anxiety) were analyzed separately. Before comparing PREFSS scores, Skewness and Kurtosis values, and Kolmogorov-Smirnov Test of the dependent variable (PREFSS) at each group (Experimental and Control) were explored to examine the validity of normality assumption (Field, 2013). According to Kolmogorov-Smirnov Test results, the normality assumption was met for all subdimensions of FSS for both experimental and control group, as the values were found non-significant. In addition, the skewness and kurtosis values indicated that pretest scores of three subdimensions were normally distributed, since the values were between -1 and +1, for both groups.

Homogeneity of variances assumption was tested using Levene's test. According to the results of Levene's test, there was no statistically significant difference between the variances of experimental and control groups for Flow subdimension (FSD) ($F = .316, p > .05$), Boredom subdimension (BSD) ($F = 1.572, p > .05$), and Anxiety subdimension (ASD) ($F = .114, p > .05$). As the assumptions were met, independent sample t -test analyses were conducted, and the results were presented in Table 3.5.

Table 3.5

t-Test Results Comparing the Groups on PREFSS

Variable	Groups	<i>N</i>	<i>M</i>	<i>SD</i>	Levene's Test		<i>t</i>	<i>df</i>	Sig.
					<i>F</i>	Sig.			
Flow	Experimental	37	16.05	2.15	.316	.576	.737	71	.464
	Control	36	15.67	2.34					
Boredom	Experimental	37	7.11	1.91	1.245	.268	.164	71	.871
	Control	36	7.03	2.27					
Anxiety	Experimental	37	7.30	2.39	.114	.737	.847	71	.400
	Control	36	6.83	2.29					

According to Table 3.5, independent samples t -test results indicated that there was no statistically significant difference between the mean scores of the experimental and control groups on FSD $t(71) = .737, p > .05$; on BSD $t(71) = .164, p > .05$; and on ASD $t(71) = .847, p > .05$. That is, the scores of experimental group and control group on PREFSD ($M_E = 16.05, SD_E = 2.15$ and $M_C = 15.67, SD_C = 2.34$); on PREBSD ($M_E = 7.11, SD_E = 1.91$ and $M_C = 7.03, SD_C = 2.27$); and on PREASD ($M_E = 7.30, SD_E = 2.39$ and $M_C = 6.83, SD_C = 2.29$) were not significantly different.

3.5.1.3. Comparison of pretest Mathematics Motivation Scale scores (PREMMS).

Before comparing the pretest Mathematics Motivation Scale (MMS) scores, Skewness and Kurtosis values, histograms, Q-Q plots and Kolmogorov-Smirnov and Shapiro

Wilk Tests of the dependent variable (PREMMS) at each group (Experimental and Control) were explored to examine the validity of normality assumption (Field, 2013). Kolmogorov-Smirnov and Shapiro-Wilk Test could not provide the normality assumption for the experimental group, while they showed the normality for the control group. However, the Skewness and Kurtosis values indicated that PREMMS scores were normally distributed for both groups, as the values were between -2 and +2 (George & Mallery, 2020). Q-Q plots showed the normality of distributions as the plots were around the line, and they were not scattered too much from the line. In addition, histograms showed that the distributions were approximately normal for both groups.

Homogeneity of variances assumption was tested using Levene's Test. According to the results of Levene's test, there was no statistically significant difference between the variances of experimental and control groups ($F = .534, p > .05$). As the assumptions were met, independent t -test analysis was conducted and the results were presented in Table 3.6.

Table 3.6

t-Test Results Comparing the Groups on PREMMS

Variable	Groups	N	M	SD	Levene's Test		t	df	Sig.
					F	Sig.			
PREMMS	Experimental	37	130.92	13.805	.534	.467	-.380	71	.705
	Control	36	132.08	12.283					

According to Table 3.6, Independent Samples t -test results revealed that there was no statistically significant difference between the mean scores of the experimental and control groups on pretest Mathematics Motivation Scale (PREMMS) scores, $t(71) = -.380, p > .05$. That is, the mean score of experimental group ($M_E = 130.92, SD_E = 13.81$) on PREMMS was not significantly different from that of control group ($M_C = 132.08, SD_C = 12.28$).

3.6. Data Collection Instruments

In order to answer the research questions, the following instruments were used:

1. Mathematics Test (MT): Pretest, Posttest and Retention Test
2. Flow State Scale (FSS): Pretest and Posttest
3. Mathematics Motivation Scale (MMS): Pretest and Posttest
4. Interview Form
5. Observations
6. Students' Diaries

3.6.1. Mathematics Test (MT).

The Mathematics Test was developed by the researcher before the implementation started. When developing the test, the researcher first determined the critical and more inclusive learning objectives in the elementary fifth grade Mathematics Curriculum (MoNE, 2017), in order to ensure content validity and to have a number of items that fifth grade students can answer in a certain time period (see Appendix F for the distribution of test items related to each objective). For this purpose, a table of specification was used. During the preparation of the test items, the cognitive domain of Bloom's Taxonomy was used. When the specification table and the selected objectives were examined, it was determined that the cognitive level of the objectives were up to the application level according to Bloom's Taxonomy. For this reason, it was decided that the items to be prepared should be suitable for the application, comprehension, and knowledge levels of taxonomy.

After deciding the objectives and cognitive levels, at least two items were prepared for each objective. Therefore, 40 multiple-choice items were included in the draft form of the test. When determining the test items, the researcher used various fifth-grade books and internet resources. Then, the researcher asked for a review of some experts from different departments (two experts from Curriculum and Instruction division, two

experts from Measurement and Evaluation division, one expert from Mathematics Education, and four elementary mathematics teachers) to provide evidence for face and content validity. According to experts' opinions, it was ensured that all items were related to the learning objectives to be measured, and all the objectives were covered in the test. Necessary regulations and changes were made in line with the recommendations of the experts, to provide face validity of the test. Some expressions in items and sequence of choices were edited considering the reviews. One of the experts suggested that the size of the words and symbols in the test should be increased, so that the regulation should be made in accordance with the MoNE Textbooks and Educational Tools Regulations (MoNE, 2015b). Accordingly, the items were arranged so that the smallest font size to be used for elementary fifth-grade students was 11 points. In addition, in line with expert opinions, the negative statements were underlined to ensure that students pay attention to the items. Finally, the distractors of some items were arranged, and the ordering of some of them was changed.

After these arrangements, the trial test was applied in three public schools in the fall semester of the 2017-2018 academic year, in order to check the clarity of the questions, the KR-20 reliability of the test, to select appropriate items in terms of discrimination and difficulty indices for the final version of the test. A total of 344 sixth-grade students who learned these objectives the previous year were applied the draft form of the test. However, the answers of students who left most of the questions unanswered and marked multiple options in most of the items were not included to analysis. Thus, the answers of 305 students were transferred to the computer document and analyzed through Test Analysis Program (TAP) to check the item and test statistics.

The item and test statistics of the trial test were presented in Table 3.7 below. Accordingly, the mean score of the trial version test was 18.39 and standard deviation was 6.66. The discrimination indices (r_{jx}) of all items were between 0.10 and 0.67, while the average discrimination index of the test was 0.39. The difficulty indices of all items were between 0.24 and 0.81, while the average difficulty index of the test was 0.46. KR-20 reliability of the test was 0.83, which means the test demonstrates a high degree of reliability coefficient (Atılgan, Kan, & Doğan, 2011).

Table 3.7

Item and Test Statistics of the Trial Version of Mathematics Test

Item No	Discrimination Index (r_{jx})	Difficulty Index (p_j)	Item No	Discrimination Index (r_{jx})	Difficulty Index (p_j)
Item 1*	0,46	0,43	Item 21*	0,63	0,67
Item 2*	0,42	0,67	Item 22	0,39	0,78
Item 3*	0,42	0,36	Item 23	0,52	0,75
Item 4	0,40	0,30	Item 24*	0,67	0,45
Item 5*	0,52	0,66	Item 25	0,10	0,28
Item 6	0,48	0,49	Item 26	0,39	0,61
Item 7	0,36	0,31	Item 27	0,24	0,30
Item 8	0,43	0,80	Item 28*	0,44	0,45
Item 9*	0,64	0,59	Item 29	0,25	0,27
Item 10	0,19	0,24	Item 30*	0,34	0,32
Item 11*	0,30	0,81	Item 31*	0,47	0,33
Item 12	0,34	0,36	Item 32*	0,34	0,42
Item 13*	0,47	0,75	Item 33	0,34	0,28
Item 14	0,41	0,34	Item 34	0,27	0,28
Item 15*	0,48	0,65	Item 35	0,25	0,29
Item 16	0,39	0,73	Item 36	0,24	0,32
Item 17	0,54	0,42	Item 37*	0,45	0,33
Item 18	0,44	0,42	Item 38*	0,44	0,38
Item 19	0,13	0,25	Item 39	0,13	0,31
Item 20*	0,36	0,56	Item 40*	0,33	0,44
Mean Score					18.39
Standard Deviation					6.66
Mean Discrimination Index (r_{jx})					0.39
Mean Difficulty (p_j)					0.46
KR-20 Reliability					0.83

(*) Represents items selected for the final version of the MT.

When selecting the items for the final version of the test, the widely used criteria for classification of discrimination indices (Ebel & Frisbie, 1991) were used in this study. As seen in Table 3.8, items that have a discrimination index below 0.20 cannot be used and should be eliminated from the test. The items that have a discrimination index

between 0.20-0.29 are acceptable with major revision, while items with a discrimination index between 0.30-0.39 are acceptable with minor revision. The items that have a discrimination index above 0.40 can be used without any revision.

Table 3.8

Interpretation of Discrimination Index

Index of Discrimination	Item Evaluation
0.40 and up	Very good items
0.30 to 0.39	Reasonably good items: little or no revision is required
0.20 to 0.29	Marginal items: usually need revision
Below 0.19	Poor items: to be rejected or improved by revision

Note. Adapted from *Essentials of Educational Measurement* (5th ed.), by R. L. Ebel and D. A. Frisbie, 1991, p. 232. Copyright 1991 by Prentice-Hall, Inc.

For the difficulty of items, there are different categorizations in the literature. In this study, more common type of categorization which is shown in Table 3.9 was used (Atılgan, Kan, & Doğan, 2011).

Table 3.9

Interpretation of Difficulty Index

Index of Difficulty	Item Evaluation
0.80 and up	Too easy item
0.65-0.79	Easy item
0.35-0.64	Moderately difficult
0.20-0.34	Difficult item
Below 0.20	Too difficult item

Note. Adapted from *Eğitimde Ölçme ve Değerlendirme*, by H. Atılgan, A. Kan, & N. Doğan, 2011, p. 298. Copyright 2011 by Anı Publishing.

According to Table 3.9, items that have a difficulty index below 0.20 are too difficult, the items that have a difficulty index between 0.20 - 0.34 are difficult; items that have a difficult index between 0.35 - 0.64 are moderately difficult, items that have a difficulty index between 0.65 - 0.79 are easy, and items that have difficulty index above 0.40 are too easy item.

When selecting the items for the final version of the test, firstly, four items (item no: 10, 19, 25 and 39) that had a discrimination index below 0.20 were removed from the test. For each of the 18 learning objectives, there was at least one item having a discrimination index greater than 0.30. Thus, for each objective to be measured, items having the greatest discrimination index and moderate difficulty index were chosen.

The item and test statistics of the final version of the test, and selected items were shown in Table 3.10 below. Accordingly, there were 18 items in the final test. The mean score of the final version of the test was 9.26, and standard deviation was 3.73. The discrimination indices (r_{jx}) of all items were between 0.33 and 0.67, while the average discrimination index of the test was 0.49. The difficulty indices of all items were between 0.32 and 0.81, while the average difficulty of the test was 0.52. KR-20 reliability of the test was 0.75. These statistics might prove that 18-item fifth-grade Mathematics Test was valid and reliable (see Appendix I for some sample items included in the test).

Table 3.10

Item and Test Statistics of the Final Version of Mathematics Test

Item No	Discrimination Index (r_{jx})	Difficulty Index (p_j)
Item 1	0,46	0,43
Item 2	0,42	0,67
Item 3	0,42	0,36
Item 4	0,52	0,66
Item 5	0,64	0,59
Item 6	0,30	0,81

Table 3.10 (cont'd)

Item No	Discrimination Index (r_{jx})	Difficulty Index (p_j)
Item 7	0,47	0,75
Item 8	0,48	0,65
Item 9	0,36	0,56
Item 10	0,63	0,67
Item 11	0,67	0,45
Item 12	0,44	0,45
Item 13	0,34	0,32
Item 14	0,47	0,33
Item 15	0,34	0,42
Item 16	0,45	0,33
Item 17	0,44	0,38
Item 18	0,33	0,44
Mean Score		9.26
Standard Deviation		3.73
Mean Discrimination Index (r_{jx})		0.49
Mean Difficulty (p_j)		0.52
KR-20 Reliability		0.75

3.6.2. Flow State Scale in Mathematics (FSS).

The Flow State Scale in Mathematics (see Appendix J) was developed by Eryılmaz and Mammadov (2016a) in order to measure high school students' flow states in mathematics. When developing the scale, the researchers conducted the draft form of the instrument to 234 high school students aged between 14 to 18. The factor analysis results showed that the FSS consisted of 3 factors, namely, Flow Subdimension (FSD), Boredom Subdimension (BSD), and Anxiety Subdimension (ASD) that explained 71.80% of total variance. In addition, the FSS has 13 items which are scored using a 4-point Likert type. The reliability coefficients of the three factors FSD, BSD and ASD were found to be 0.91, 0.83 and 0.81 respectively. The researchers suggested that the scale should be used in terms of its factors rather than measuring total score since the correlations among the factors were not significant. The maximum score one can take

from the flow factor is 20 while the minimum score is 5; the cutting score can be taken as 10 for this factor. The maximum score one can take from boredom factor is 16 and the minimum score is 4; the cutting score is offered as 8. Lastly, one can take a maximum score of 16 and a minimum score of 4 from the anxiety factor; the cutting score is determined as 8 by Eryılmaz and Mammadov (2016a).

Since the subjects of this study and the participants with whom the FSS was developed had different developmental attributes and different ages, the adaptation of the scale was performed before the implementation, in order to investigate the construct validity. For this purpose, the scale was administered to 380 fifth-grade students from two public schools (different from the implementation school) in the fall semester of 2017-2018 academic year. The data were analyzed through Exploratory Factor Analyses (EFA) using SPSS.22 program, and Confirmatory Factor Analyses (CFA) using LISREL 8.8 program.

In order to determine the factor loads of the items and to determine which factors they belong to, first EFA was conducted. To determine the suitability of the data for factor analysis, Keiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity were examined. The KMO measure of sampling adequacy of .88 was greater than .60 (Tabachnick & Fidell, 2013). This result tells us there were enough items under each factor in the scale (Leech, Barrett, & Morgan, 2008). Also, Bartlett's test was significant ($X^2 = 2006.895, p < .05$), showing that the correlation matrix was significantly different from an identity matrix. Thus, it can be inferred from both results that it was appropriate to conduct exploratory factor analysis.

In the EFA, principal axis factor analysis with varimax rotation was conducted to assess the underlying structure for the thirteen items of the FSS. Three factors were requested based on the fact that the items were designed to index three constructs: flow, boredom and anxiety. As shown in Table 3.11 below, factor loadings for Factor 1 were ranging from .496 to .785, for Factor 2 from .566 to .709, for factor 3 from .536 to .709, which were significant (Hair et al., 2010). After rotation, the first factor accounted for 19.42% of the variance, the second factor accounted for 16.96%, and the third factor accounted for 14.36%.

Table 3.11

Factor Loadings from Factor Analysis of the Flow State Scale

Item	Factor Loading			Communality
	1	2	3	
1	.77			.55
2	.79			.61
3	.50			.25
4	.51			.26
5	.61			.44
6		.59		.38
7		.57		.34
8		.71		.46
9		.69		.44
10			.63	.55
11			.60	.49
12			.71	.59
13			.54	.50
Eigenvalue	5.22	1.85	.95	
% of variance	36.67	10.45	3.62	

In Table 3.12 below, the standardized solutions of three-factor Flow State Scale by CFA results were given. In the right-most column of the table, *t* values were presented which show the significance of the estimated factor loads. The results of CFA confirmed the structure that set out in EFA.

Table 3.12

Standardized Solutions by CFA of FSS for the Three-Factor Model

Item	Factor			<i>t</i>
	Flow	Boredom	Anxiety	
1	.79			17.39
2	.85			19.25
3	.49			9.42
4	.49			9.58

Table 3.12 (Cont'd)

Item	Factor			<i>t</i>
	Flow	Boredom	Anxiety	
5	.68			14.18
6		.65		12.87
7		.62		12.11
8		.73		14.80
9		.69		13.82
10			.79	17.64
11			.73	15.67
12			.80	17.97
13			.73	15.61

In Figure 3.2, Figure 3.3 and Table 3.13 below, the results of CFA and goodness-of-fit indicators of the models for the Flow State Scale were demonstrated.

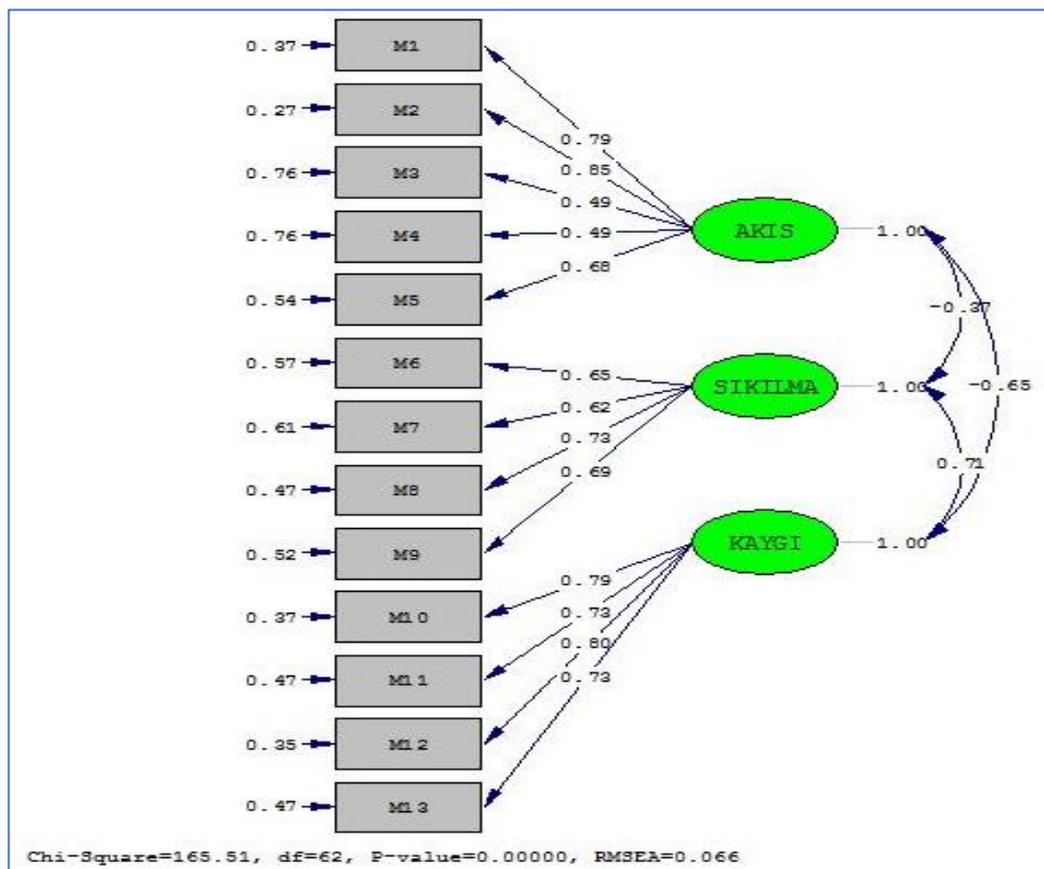


Figure 3.2. Confirmatory factor analysis and standard values of FSS

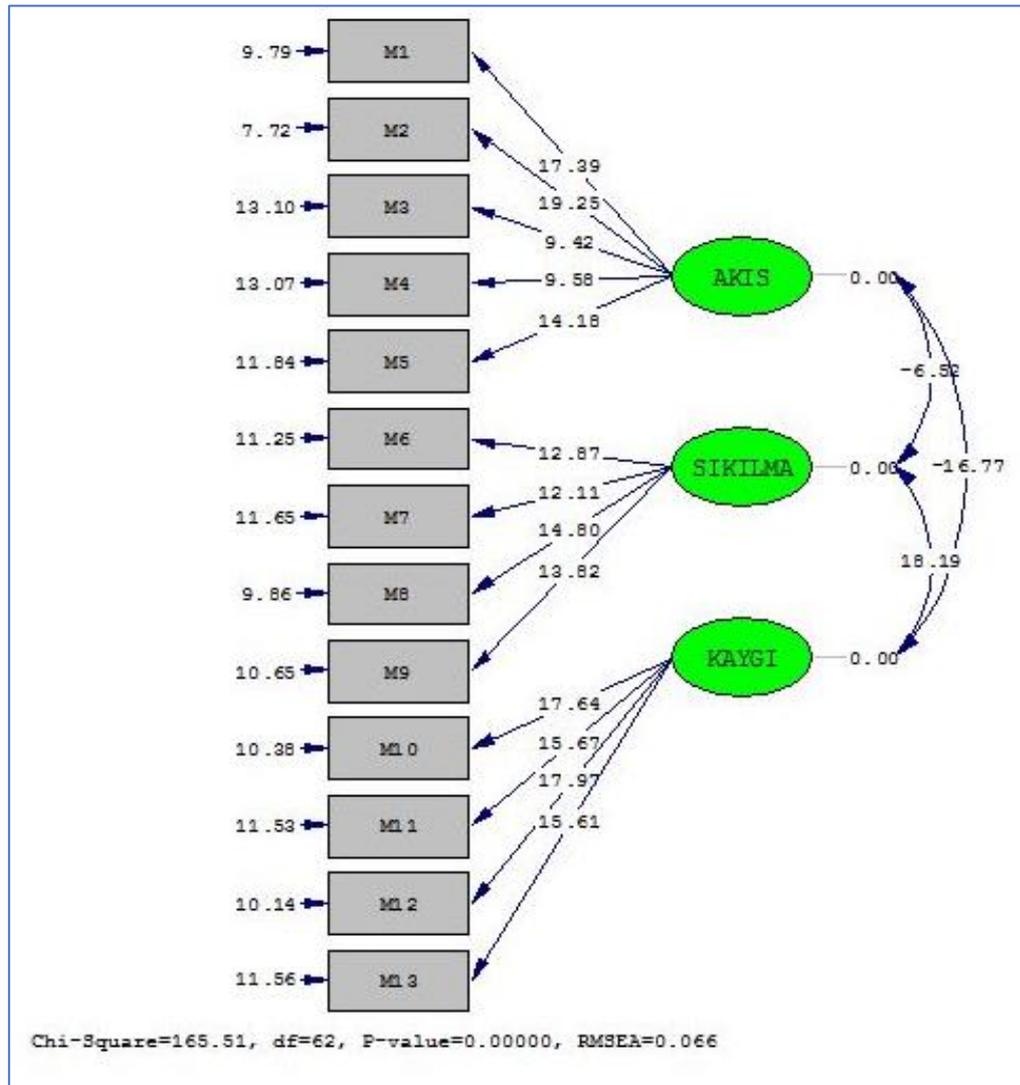


Figure 3.3. Confirmatory factor analysis and *t* values of FSS.

According to Table 3.13 below, the CFA results confirm that Flow, Boredom and Anxiety Factors are the components of a structure called *Flow State*. The Goodness-of-Fit indexes were found as; $\chi^2 = 165.51$; $\chi^2/df = 2.67$; $p = 0.00$; ECVI = 0.59; NFI = 0.96; NNFI = 0.97; CFI = 0.97; IFI = 0.97; GFI = 0.94; AGFI = 0.91 and RMSEA = 0.066. These values of indexes prove that the measurement model is acceptable (Schermelleh-Engel, Moosbrugger, & Müller, 2003).

Table 3.13

Goodness-of-Fit Indicators of the Models for The Flow State Scale (N=380)

<i>Model</i>	<i>df</i>	X^2	X^2/df	AGFI	ECVI	RMSEA
Three Factor	62	165.51***	2.67	0.91	0.59	0.066

Note. AGFI = adjusted goodness-of-fit index; ECVI = expected cross-validation index; RMSEA = root mean square error of approximation.

*** $p < .001$

For the reliability of 13 items of FSS, Cronbach Alpha internal consistency reliability coefficients were calculated. The internal consistency reliability coefficient for the Flow factor was found as 0.78; for the Boredom factor as 0.77 and for the Anxiety factor as 0.85. The number of items and the reliability coefficients for each factor were given in the Table 3.14 below. Since the predictions regarding the reliability of the factors should be above .70 (Nunnally, 1978; Hair et al. 1998), there is sufficient evidence for the internal consistency reliability of the factors in the scale.

Table 3.14

The Number of Items and Reliability Coefficients of The Factors

Factors	# of items	α
Flow	5	0.78
Boredom	4	0.77
Anxiety	4	0.85
Total	13	-

3.6.3. Mathematics Motivation Scale (MMS).

The Mathematics Motivation Scale (MMS) (see Appendix K) was developed by Tahiroğlu and Çakır (2014) to measure elementary education fourth-grade students' mathematics motivation. Since the subjects of this study and the participants with

whom the scale was developed had similar developmental characteristics and similar ages, the adaptation of the scale was not performed (Boztunç Öztürk, Eroğlu, & Kelecioğlu, 2015). When developing the scale, the researchers collected data from 299 students in 2013-2014 academic year and conducted required analyses. Accordingly, the MMS has 5 factors (motivation to be appreciated, motivation towards interest, desire and needs, motivation towards developing self-confidence, motivation for success, motivation for goal) which explain 51.93% of total variance and 32 items that are scored using a 5-point Likert type scale named as strongly agree, agree, not certain, disagree, and strongly disagree. In addition, the Cronbach Alpha reliability coefficient of the factors were found as 0.91, 0.92, 0.89, 0.85 and 0.70, respectively. The internal consistency reliability of MMS was determined to be 0.93. In order to check the test-retest reliability, the researchers conducted MMS to 157 students after four weeks. The number of items and the reliability coefficients of factors were given in the Table 3.15 below.

Table 3.15

The Number of Items and Cronbach Alpha Coefficients of the MMS

Factors	# of items	α	r (test-retest)
Motivation to be appreciated	5	0.91	0.86
Motivation towards interest, desire and needs	7	0.92	0.82
Motivation towards developing self-confidence	6	0.89	0.80
Motivation for success	8	0.85	0.85
Motivation for goals	6	0.70	0.69
Total	32	0.93	0.91

As seen in Table 3.15, the reliability coefficient of the scale was found to be 0.91, while the reliability coefficients of the factors were found as 0.86, 0.82, 0.80, 0.85 and 0.69 respectively, after test-retest analysis (Tahiroğlu & Çakır, 2014). These scores proved that the MMS was adequately reliable (Hair et al. 1998; Nunnally, 1978).

3.6.4. Interview form.

The interviews help us to obtain information that cannot be directly observed from the perspective of the students, and to gain an in-depth and holistic perspective on a subject (Patton, 2014/2002). In order to learn thoughts and views of the students about the process, activities, and experiences during the instruction designed according to Flow Theory principles, a semi-structured interview form (see Appendix L) was prepared by the researcher. The form consisted of 11 questions which were arranged in an open-ended format. In the interview, attention was paid to ensure that the questions asked to the students were as clear, understandable, and simple as possible. In the interview, probes were included in order to obtain richer and more in-depth data from the participants (Yıldırım & Şimşek, 2011), and to provide more concrete examples. These probes guide the interviewee and allow the interviewer to control the flow of the interview process (Patton, 2014/2002).

The researcher asked for a review of five experts (one of which from Curriculum and Instruction division and conducting graduate level qualitative research courses, two experts from Guidance and Counseling division and two mathematics teachers) in order to determine the appropriateness of the questions and probes for the fifth graders' understanding. After regulating some of the expressions in the questions in accordance with the experts' views, the form was piloted with three fifth-grade students. The words and expressions which could be misunderstood or could not be understood were changed, or synonymous of them were added as a description.

3.6.5. Observation form.

Observation, which is an important data collection method for qualitative data, helps the researcher to have information about events, activities, and interactions between individuals, as there are limits what can be learned from what people say (Patton, 2014/2002). The purpose of the observations in classroom is to make in-depth and detailed explanations and definitions about the event, phenomenon and situation that is the subject of the research, to define in detail the learners' behaviors with a holistic understanding during the experimental process applied in the study (Yıldırım &

Şimşek, 2011) and to use them to support and make sense of data obtained from other qualitative and quantitative data.

The researcher was present at classroom during the experiment process in order to observe situations such as the reflections of Flow Theory principles in the classroom environment, how the teacher applies the experimental procedure material, and the participation and reactions of the students regarding the applied experimental procedure. For this purpose, a framework in line with the research questions of the study was prepared and used by the researcher (see Appendix M). While creating the observation form, first of all, a detailed examination of the studies in the literature was made. Since it is not possible to observe everything that happens in the classroom during the observation process, the points on which the observations should be focused were determined.

The observation form consists of two columns. In the first column, there are definitions and examples of the basic elements of the instruction developed based on Flow Theory, such as skill-challenge balance, focused attention, concentration, learner control, attractiveness, clarity of objectives, feedback qualities, autotelicity, and immersion in the classroom environment. In the second column, there are notes about the sample situations and experiences observed by the researcher regarding these definitions.

3.6.6. Students' diaries.

In the study, the experimental group students were asked to write a diary about mathematics lessons. The diaries are considered as a research tool and alternates the self-reports and questionnaires (Pearson-Evans, 2006). The diaries of students were used for triangulation of data to be collected from other data collection tools. For this purpose, the students were asked to briefly write about how they felt in mathematics classes, their thoughts about activities, and what they learned in class. The diaries were collected weekly from the students and transferred to the computer document.

3.7. Experimental Process Material

Lesson plans and activities were prepared by the researcher in the fall semester of 2017-2018 academic year (See Appendix N for sample lesson plan and activity). They included the learning areas and topics to be taught in the experimental process. When preparing the lesson plans, the researcher considered the principles of Flow Theory, and used RME approach. When the literature on Flow Theory was reviewed, none of the studies included an example of how to design mathematics instruction in accordance with the theory. In some of the studies, the instructional practices carried out by different teachers were observed in detail, and inferences were made on which of these enable students to enter more flow state and have more motivation (Challco et al., 2016; Gunderson, 2003; Schweinle et al., 2006; Su & Hsaio, 2015; Turner et al., 1998). It is seen that the studies on Flow Theory are generally on to what extent the current teaching practices cause flow experience on students (Ak Şentürk, 2010; Armstrong, 2008), or whether some techniques used in teaching contribute to flow experience (Admiraal et al., 2011; Alperer, 2005; Aremu & Adebago, 2016; Chan & Ahern, 1999; Kalay, 2013; Su & Hsaio, 2015). Based on the results obtained from this literature review and suggestions of researchers, inferences were made about how to design an instruction based on the Flow Theory and what features it should have. Later, an instructional design for the mathematics was prepared by considering the instructional practices that handled by Chan & Ahern (1999), Linnenbrink-Garcia et al. (2016), Rezabek (1994), and Schweinle et al. (2006) and task design that was made by Guan (2013).

At this point, since RME has a great parallelism with flow-like experiences and it is considered as a special teaching approach in mathematics, the features of RME approach were also employed as a guide in instructional design to attract learners' attention, emphasize the importance of the task, and ensure meaningful and long-lasting learning (Gravemeijer, 1997; Uygur, 2012). While preparing the lesson plans, the studies on RME were examined in the literature, and some lesson plan examples suggested by these studies (Arseven, 2010; Cihan, 2017; Kurt, 2015; Uça, 2014) were used. When the lesson plans and the activities were prepared, the researcher asked for a review of experts from different domains: Two experts from Curriculum and

Instruction department, one expert from Elementary Education department, one expert from Computer and Instructional Technologies department, and three elementary mathematics teachers. The experts gave feedback about the lesson plans in terms of content, suitability of the activities with the learning objectives, RME approach, students' developmental level, the language used, etc. In line with the suggestions of the experts, some changes were done, for instance the duration and content of the activities, wording of the real-life cases, problems, shapes, figures and tables in the activities etc.

Instructional strategies which are related to Flow Theory and used in the preparation of activities and lesson plans are as follows: Keeping the challenge-skill balance, providing feedback, supporting learners' autonomy, encouraging positive affect, fostering social relationships, and making the content relevant and interesting for the learners. Undoubtedly, one or more of these elements might be used in different ways and amounts in any class environment, however, in an instruction developed based on Flow Theory, as many of these elements as possible should be used together. As Schweinle et al. (2006) advocate that such elements together are likely to have multiplicative effects, each reinforcing the other, thus learners react to the conditions formed by the holistic effect of these elements. While designing the instruction, it was planned to make the lessons play- or game-like in order for the following strategies to be useful for increasing students' motivation in mathematics and enabling them to experience the flow state in mathematics. These strategies are explained in the following paragraphs.

3.7.1. Keeping the balance between challenge and skill.

As can be understood from the words "If the student is lacking in understanding or in interest, it is not always his fault, the problems should be well chosen, not too difficult and not too easy" by Polya (2015, p.6), it is very important to balance the challenge level of the activities and problems used in the teaching of mathematics lesson and the skill levels of the students. While preparing lesson plans and activities for mathematics instruction, it was ensured that the level of language, materials and problems used were suitable for the level of fifth-grade students. According to Ausubel and Robinson

(1969), since mathematical concepts and operations have a great deal of sequential interdependence and gradualism, learners can only advance in new subjects after gaining sufficient knowledge and experience in the prerequisite ones. Therefore, mathematics instruction in the current study actually gives the teacher the opportunity to adjust the difficulty of the tasks according to the skill levels of the students in this sequential progression process. In other words, in the teaching of mathematics in this study, the teacher aimed to keep the students within the flow channel specified by Csikszentmihalyi (1990) by adjusting the challenge level according to the skill levels of the students with the questions she asked.

Teaching activities were tailored to a level that students can understand, to try out methods or studies similar to the re-invention of mathematics used during the implementation of *guided reinvention*. For this reason, activities have been prepared to teach new subjects by connecting them with pre-learning of students (Anderson, 1982). Moreover, the activities and problem contents contained examples that students may encounter in real life, suitable for the environment they live in, or that will attract the attention of this age group. These math problems were mostly open-ended, students can propose different solutions and enable them to learn the subject with their own speed. Additionally, the activities provided opportunities for students to show their skills. The tasks and activities were prepared as complex and cognitively demanding as possible for the subjects of the study (Dolezal, Welsh, Pressley, & Vincent, 2003).

During the lesson, students were often reminded by the teacher that it is more important to understand mathematical tasks and concepts rather than memorizing or rote learning of them, and as a result, their skills will improve. During the activities, the teacher provided scaffolding to students, set up appropriate time for students to complete the tasks, split long term or difficult tasks into simpler units in order to decrease the difficulty of the tasks, which follows Vygotsky's principles (Schweinle et al. 2006; Schweinle, & Bjornestad, 2014). Scaffolding of instruction helps learners turn into coparticipants in both teaching and learning process. At the same time, it helps to provide flow experiences by supporting the complex relationships between cognition, motivation, and emotions, contributing to students' learning for learning's own sake (Turner et al., 1998).

3.7.2. Providing clear and immediate feedback.

The activities used during the instruction of the mathematics included situations that provide clear, supportive, constructive, and timely feedback to students. Feedback in the experimental class aimed to inform students during the activities rather than controlling their behavior and was put to work when they needed it (Heine, 1997). Some learners need certain feedback more often and repeatedly. Since this helps to complete the conceptual structure that the student is trying to create in his mind and to solve the problem he encounters, the feedback contributes to the development of the student in accordance with his own learning pace (Brandl, 1995).

In order to create such a feedback environment, the teacher always reminded the students that they should help each other before and during the activity, and that this would both help them learn themselves and increase the success of their groups. Therefore, it was ensured that the questions required for effective feedback (where am I going, how am I going and where to next?) were asked and answered (Hattie & Gan, 2011). For example, before starting each activity, students were reminded to discuss the aims of the activity among themselves and to ask the teacher about unclear points. During the activity, the teacher was constantly walking around the classroom, following the progress of the students, guide them to process information and to construct meanings. Additionally, the teacher encouraged the students to share their answers with each other by creating a discussion environment at the end of the activity, and at the same time asked them questions such as "Who would like to contribute or comment on your friend's answer?", enabling them to turn mistakes into opportunities for learning. This creates additional opportunities for students to receive immediate feedback from their peers during the activities and problem solving process (Golnabi, 2017).

3.7.3. Supporting learners' autonomy/control.

In the courses based on Flow Theory, the learners had an autonomous learning environment in many ways, since the opportunity of control provides learners less anxiety and boredom, more motivation (Steinberg, 1977; 1989). This control provided to learners includes controlling the learning pace, sequencing, guidance, design, and

location (Karim & Behrend, 2013). In terms of location control, the students had the right to move to groups where they could work more freely and efficiently, without hindering group dynamics and heterogeneous distribution, in the groups formed at the beginning of the lesson. In terms of design control, the students were supported for autonomy in order to determine the distribution of tasks within the group. That is, students were given the chance of negotiating and playing the roles (such as scribe, encourager, leader etc.) that best suit them given the task at hand without teacher intervention (Armstrong, 2008).

While the students completing their work in groups, they were free to control the pace of the activity according to their own learning, only if it did not hinder the flow of the lesson and the learning of other students. In terms of guidance/advisory control, the learners were given positive and constructive feedback to freely express their ideas, no matter which solution they used regarding the activities. Regardless of whether it is true or false, they were reinforced by the teacher and their peers to answer the questions posed to them and express their opinions about the problems in the activities. In almost all cases, students were made to feel that they were not judged or evaluated for their mistakes or incomplete answers, and that these were an opportunity to ensure correct learning and to clarify those that were misunderstood (Schweinle et al. 2006). As observed in learning environments with high flow experiences, the teacher directed the students to express their solution strategies and ways of thinking. Thus, it was aimed to make the students take decisions that will direct their own learning. For this purpose, the teacher guided students towards autonomous learning by exploring possible strategies with students, asking *why* and *how* questions in order to evaluate their understanding, to justify the strategies and to show their learning. (Turner et. al., 1998). Finally, in terms of sequence control, students were given autonomy to decide between the order of the steps they need to carry out during the activities. However, in activities where the order between the activity steps is important, this situation was announced to the students, and they were reminded to follow the determined steps. On the other hand, content control could not be given to students, as the objectives in the mathematics curriculum could not be exceeded within the scope of the study. In addition, since the mathematics lessons had to be held on the days and hours

determined by the school, the learners were not provided with time control (Karim & Behrend, 2013).

3.7.4. Encouraging positive affect.

In instruction based on Flow Theory, students should be made to feel that there is a positive affective climate in the classroom so that they willingly and fondly participate in activities and have intrinsic motivation (Schweinle et al. 2006). As offered by Dolezal et al. (2003), creating a warm, caring atmosphere for learning might help students engage in the tasks and activities, think deeply, take risks and challenge their abilities. Therefore, by encouraging students to help each other on both cognitive and motivational issues, situations that could be an example of positive affective support were made widespread to attract the attention of the whole class. For this purpose, group studies and collaborative activities, which require students to interact with their peers including high trust and empathy among group members and teacher, were used in flow-based instruction practices. The way to ensure interaction between students was provided by presenting activities that would challenge them to a certain level. Thus, the students felt the need to communicate with their friends in the group in order to overcome these difficulties. If their friends could not come up with a solution, the students contacted the teacher and requested feedback. On the other hand, whole-class discussions held at the end of each lesson, the students were guided by the teacher to express their opinions on each other's answers. Here, students were made to feel and reminded that it was not a problem for them to give wrong or incomplete answers. In addition, some humor and fun aspects were also included in the stories used in the activities and in the language used by the teacher. Additionally, in instruction based on Flow Theory, grading and evaluation were not used as a weapon that students would be afraid of. By emphasizing the importance of learning at every opportunity to students, it was tried to alleviate their pre-existing frustrations, fears and giving up feelings about mathematics.

3.7.5. Fostering social relationships.

As Wentzel & Watkins (2011) stated, children who communicate and interact with their peers can get companionship and entertainment. One of the basic teaching

principles of RME, the principle of interaction-cooperation, advocates that learning mathematics is a social activity, so students can access higher level knowledge by discussing problems with other learners and building on each other's knowledge (Heuvel-Panhuizen & Drijvers, 2014). In addition, there are studies in the literature showing that cooperative learning is indispensable for learning environments that ensure flow (Gwyn, 2004). Therefore, in the experimental group, mathematics instruction was carried out through group work and cooperative learning in all lessons and activities. Learning activities were planned to ensure that students work together to achieve common goals in the group and support each other in terms of motivation (Slavin, 2011) and cognitive skills such as problem solving and retention of knowledge (Wentzel & Watkins, 2011).

Group studies were formed according to the subject and the objectives to be taught. For example, these were sometimes used in the teaching of subjects as a concrete product put forward by the group members together, and sometimes as problems for which the groups suggested creative solutions. After the activities, the solutions and products that were put forward were discussed within and between groups. During these discussions, the teacher supported students to build on each other's answers by asking questions such as "Why do you think your friend thinks this way?", "Who wants to remind your friend what ... is, without giving him the answer?". (Schweinle et al. 2006).

3.7.6. Making the content relevant.

Another property expressed in the literature about flow is that students experience more intrinsic motivation and flow in activities or tasks that have content relevance for them (Chan & Ahern, 1999). Students should feel that the topics and content they will learn are suitable for their interests and developmental level, and they should have fun while learning these topics. Therefore, RME was used for the design of the activities and instruction that attract the attention of the students in the experimental group and make them feel that the content they would learn was important. The core principles of teaching (activity, reality, and level) proposed by the RME have also been highlighted in the literature as appropriate to achieve this (Middleton, 1995).

Therefore, the experimental group students learned mathematical concepts through hands-on activities, by doing and rediscovering mathematics. They were presented with *real* or *as if real* problems in activities, and they were asked to produce solutions appropriate to their levels (Heuvel-Panhuizen & Drijvers, 2014). Due to the age and development level of the subjects under study, elementary fifth grade students love playing, like to move, need to communicate with friends, have fun, and are interested in technological tools and equipment. Therefore, several materials and technological tools were employed in order to attract students' attention in the lessons. In the teaching of students in the elementary school period, especially play-like learning activities have a great importance, and Flow Theory has made a great contribution to the design of the teaching activities as play-like (Block, 1984). Experimental group students were applied activities as playing games in which they should be physically active, test and increase their abilities, explore experiences, at the same time, for them to learn while having fun and to provide intrinsic motivation (Engeser & Schiepe-Tiska, 2012). It was thought that the play settings for flow activities would be effective in ensuring that the students participate voluntarily, feel exciting and find personally meaningful. For this reason, while preparing the instructional design, attention has been paid to include activities that meet such needs.

3.8. Preparatory Work in the Experimental Group Before the Application

In order to help students in the experimental group adapt to the mathematics instruction based on Flow Theory, gain experience, and apply the mentioned principles effectively and accurately, the experimental group was taught based on Flow Theory principles for two weeks before the actual experimental application started. During this adaptation practice, the students' questions were answered by the researcher, and they were informed in detail about how mathematics lessons to be conducted, the roles of the teacher and students, and the properties of the activities to be done.

First, considering that the students had never participated in group study before, practical training was given on issues such as what group study is, how it should be done, cooperation in the group, division of labor, giving feedback, and discussion. In addition, it was stated that the students can control the work they do in the group as

they wish, and they can determine the subjects such as division of labor, task distribution and process steps within the group. They were reminded that they will have complete autonomy to express their opinions in any discussion environment in the classroom and will not be subjected to any penalty or low grade for their incomplete or incorrect answers. On the contrary, it was stated that other students in the class should always support each other in order to complete or correct these wrong and incomplete answers. Thus, it was aimed for the students to participate in the lesson according to their own wishes instead of rewards and punishments.

3.9. Teacher Training in the Experimental Group

Since the teaching based on Flow Theory will be carried out by the same teacher who teaches the mathematics lessons of the experimental and control groups, necessary information was given to the teacher before the application. She was reminded that she should not talk about the experiment in the control group, and two groups should not interact as much as possible during the experimental process. Before the application, information was shared about the principles of Flow Theory, implementation of RME, the points to be considered in the application of these principles, the studies about Flow Theory, the classroom environment in instruction based on Flow Theory, the roles of students and teacher, the characteristics of teaching activities and materials to be used, and some details of the experimental study to be carried out. This information sharing lasted about three weeks, and the teacher and the researcher came together frequently during this process and held meetings about the study. The prepared activities and teaching materials were shared with the teacher, and the teacher was asked to give feedback about them. The final form was determined by making the necessary changes (duration, order, content, etc.) of the activities in line with the feedback and corrections given by the teacher. It was reminded that the teacher could apply to the researcher whenever she was curious or asked for help both before and during the application, and the researcher provided the necessary guidance in this regard.

3.10. Instruction in Control Group

Before the application of experimental process, the instruction of teacher in the control group was observed by the researcher for two weeks. The purpose of these

observations is to see how the teacher teaches in the control group, what methods and techniques she used. Apart from this, the researcher did not intervene in the control group, and tried to prevent interaction between the experimental and control groups as much as possible. The researcher came together with the control group students only in the pretest, posttest and retention test applications of the data collection tools.

In the control group, it was observed that the lessons were taught in line with the subjects and objectives in the fifth grade Mathematics Curriculum approved by MoNE (2017). However, although the basic skills accepted in the curriculum are suitable for constructivist approach, the method used by the teacher did not go beyond the traditional method for the most part. Thus, the teacher has never used group studies or cooperative learning activities, and concrete materials. In this group, the teacher used only teacher-centered methods, such as lecturing, question and answer. Immediately after the lecture of the subject, exercises were performed by using the question and answer technique by reflecting the questions from the book on the smart board. The students wrote down what the teacher said during the lecture in their notebooks, and each student tried to solve the questions individually during the question and answer phase. Then, they were given a certain amount of time to solve each question. Afterwards, the teacher wanted them to show the solution on the board by choosing randomly one of the students who wanted to solve the question. After the correct answer was marked by the student, other students were transferring the solution of the question to their notebooks. After the solution of each question, the teacher moved to the next questions and this process was repeated until the end of the lesson.

During the lectures and exercises about the mathematics topics, it was observed that the students were constantly competing with each other for purposes such as finding the result in the fastest way, writing the solution by getting up to the board and then gaining the teacher's appreciation. In addition, while the teacher expressed the points which she thought to be important, she tried to motivate the students to listen to the lesson by means of external motivation. It was also observed that she rewarded students who answered some difficult questions correctly with a plus or a star. Additionally, there was mostly silence in the classroom, and students were not allowed to speak unnecessarily and disrupt the atmosphere of the lesson by giving penalties

such as not allowing them to stand up to solve the next question or getting a minus. Students were only allowed to talk and ask questions about subjects they did not understand. They could reach the teacher about the subject they did not understand during or after the lesson. Therefore, students seemed to avoid helping and interacting with each other until the correct result was shared on the board. Also, the number of students who were able to solve the questions was generally less than half of the class, and the others were just busy writing the solutions written on the board. It was observed that the teacher tried to solve as many questions as possible in a class hour. The questions that were not solved within one lesson hour were given to the students as homework, and they were checked in the next lesson.

3.11. Data Collection Procedures

For the purpose of study, the researcher prepared an instruction. The experimental group was taught with instruction designed in accordance with Flow Theory and enhanced with RME from the beginning to the end of the experimental process, while the control group were not given any intervention and learned the same units and objectives in the curriculum approved by MoNE.

The instruction to be applied covered two learning areas (Numbers and Operations, Geometry and Measurement) which included five topics (Percentages, Basic Geometric Concepts and Drawings, Triangles and Quadrilaterals, Measurement of Length and Time, Measurement of Area) of the fifth-grade mathematics curriculum in the spring semester of academic year 2017-2018. The instruction included play-like activities integrated with real-life examples in which flow was intensively observed such as cooperative learning, immediate feedback, technology supported applications and soft-ware, and concrete materials as proposed by Flow Theory and RME approach. Before the instruction to be applied, the teacher was informed about the Flow Theory, its principles and effects, and how to conduct instruction in experimental group. Several research and presentations were shared with the teacher, in order to provide understanding about Flow Theory.

When deciding the experimental and control groups, MMS, FSS and MT were applied as pretest at the beginning of the second semester, in order to compare their

equivalency. For this purpose, pretest scores of three data collection tools were analyzed through independent samples *t*-test. The *t*-test results showed that the groups did not statistically differ. Therefore, one of the classes was randomly assigned as the experimental group, while the other as control group.

Table 3.16

Data Collection Procedures

Duties	Weeks	Groups	
		Experimental	Control
Control of Equivalency of the Groups	05-09.02.2018	MMS, FSS, MT	MMS, FSS, MT
Topic1: Percentages	12-16.02.2018	Diaries, Observation	-
Topic1: Percentages	19-23.02.2018	Diaries, Observation	-
Topic 2: Basic Geometric Concepts and Drawings	26.02-02.03.2018	Diaries, Observation	-
Topic 2: Basic Geometric Concepts and Drawings	05-09.03.2018	Diaries, Observation	-
Topic 2: Basic Geometric Concepts and Drawings	12-16.03.2018	Diaries, Observation	-
Topic 3: Triangles and Quadrilaterals	19-23.03.2018	Diaries, Observation	-
Topic 3: Triangles and Quadrilaterals	26-30.03.2018	Diaries, Observation	-
Topic 4: Measurement of Length and Time	02-06.04.2018	Diaries, Observation	-
Topic 4: Measurement of Length and Time	09-13.04.2018	Diaries, Observation	-
Topic 5: Measurement of Area	16-20.04.2018	Diaries, Observation	-
Topic 5: Measurement of Area	23-27.04.2018	Diaries, Observation	-
Posttests	30.04-11.05.2018	MMS, FSS, MT	MMS, FSS, MT
Student Interviews	28.05-01.06.2018	Interview Form	-
Retention Test	17-28.09.2018	MT	MT

3.12. Steps of Experimental Process and Data Collection

The experimental process steps of the research and the steps followed in the data collection process were as follows:

1. Considering the objectives of related learning areas in the fifth grade Mathematics Curriculum (MoNE, 2017), an instructional design was prepared in accordance with the principles of Flow Theory and by making use of RME.
2. Within the scope of this design, daily lesson plans and activities to be implemented in a total of 11 weeks were prepared.
3. The instructional design prepared was asked for expert opinions (two experts from Curriculum and Instruction Department, one expert from Elementary Education Department, one expert from Computer and Instructional Technologies Department, and three elementary mathematics teachers), and necessary arrangements were made in line with expert opinions.
4. Mathematics Test was developed by the researcher, which included the objectives in the curriculum, and the final form was prepared as a result of expert opinions and pilot tests.
5. The school where the experiment was conducted and the mathematics teacher who carried out the mathematics lessons were determined, and the necessary legal permissions were obtained from METU Human Subjects Ethical Committee, Izmir Provincial Directorate of National Education, and school administration.
6. Meetings were held for the necessary information and sharing, and course materials and activities were introduced to the teacher who will carry out the experiment.
7. Data collection tools (MT, FSS and MMS) were applied simultaneously to the two fifth-grade classes in which the same teacher carried out their mathematics courses. Accordingly, it was determined that both groups were equivalent to each other in terms of measured variables, and the groups were randomly assigned as experimental and control group.

8. Before the experimental process started, two weeks of adaptation was applied to the experimental group students in order to adapt to the teaching in accordance with the Flow Theory and RME.
9. The experimental application lasted 11 weeks in total. While no intervention was made to the control group in this process, the instruction applied in the experimental group was observed by the researcher.
10. Measurement tools were applied to both experimental and control groups as a posttest immediately after the experimental application was completed. Considering the scores of the experimental group in the achievement test, ten students (with upper, middle and lower academic achievement) were determined, and face-to-face interviews were conducted with these students.
11. Four months after the posttests, Mathematics Test was applied to the experimental and control group students as retention test.

3.13. Data Analysis

In this section, the analysis process of quantitative and qualitative data is mentioned separately.

3.13.1. Quantitative data analysis.

In this study, various data analysis techniques were conducted in order to answer research questions. Pretest data obtained from MT, FSS and MMS were analyzed with independent samples *t*-test to determine whether the groups were equivalent before the experiment. The descriptive statistics were used to give information about the experimental and control group on achievement, flow state and motivation in mathematics.

Later, in order to answer the first research question, a 3 (pretest, posttest and retention test) x 2 (Groups) Mixed Between-Within Subjects of Analysis of Variance (ANOVA) with repeated measures was conducted for the Mathematics Test scores, at the level of significance $p = .05$.

To answer the second and third research questions, a 2 (Pretest and Posttest) x 2 (Groups) Mixed Between-Within Subjects of Analysis of Variance (ANOVA) with repeated measures were conducted, at the level of significance $p = .05$. In order to explain some significance values that emerged in the ANOVAs, t -tests for paired samples and independent samples were conducted. Statistical Package for Social Sciences (SPSS) 25.0 was used to analyze quantitative data.

Mixed design of ANOVA is one of the appropriate statistical tests when you have a mixture of between-group and repeated-measures variables (Field, 2013). Mixed ANOVA analysis involves obtaining data for the same variable at different times, from subjects in different groups, and tests the between-subjects, within-subjects and the interaction of both variables, to investigate whether the effect of testing time within each group differs (Tabachnick & Fidell, 2013; Tolmie, Muijs & McAteer, 2011).

3.13.2. Qualitative data analysis.

In qualitative research methods, the steps such as collection and analysis of data, reporting of results are not independent from each other, but they are conducted simultaneously (Creswell, 2013). In addition, the analysis of qualitative data, unlike in quantitative approach, requires going back and forth in the data set, and possible coding schemes come into play from the beginning of data collection, and this process goes on until the end of coding and analysis of the entire data set (Braun & Clarke, 2006). There are no clear and agreed-upon terms to describe the diversity and processes in qualitative analysis (Patton, 2014/2002). Analyzing qualitative data is a creative process and not as precise as in quantitative research. The patterns and themes to be found among the data are based on the researcher's interpretation and how he organizes them (Yurdakul, 2004).

In this study, the qualitative data obtained from semi-structured interviews, observations, and students' diaries were analyzed through Thematic Analysis approach. Braun and Clarke (2006, p.6) define thematic analysis as "a method for identifying, analyzing, and reporting patterns (themes) within data". One of the most distinctive and useful characteristics of thematic analysis is that it has flexible structure, since it adapts to both essentialist and constructionist paradigms. Thus,

thematic analysis provides a research tool for the researcher to interpret the data in a rich and detailed way (Braun & Clarke, 2006).

In this study, both deductive and inductive thematic analysis types were conducted for the analysis of data. In deductive or theoretical thematic analysis, the data are handled with themes and patterns that are compatible with the theoretical framework of Flow Theory, the effect of which is examined in the study, while in inductive analysis, it is aimed to discover new patterns, themes and categories within the data (Patton, 2014/2002). In the theoretical thematic analysis process, the researcher focused more on some aspects of the obtained data set, while in the inductive analysis, he made an in-depth and rich description of the entire data set (Braun & Clarke, 2006).

In the analysis of qualitative data with thematic approach, the six-step framework proposed by Braun and Clarke (2006, p.16-23) was used. These steps are defined in the following paragraphs.

3.13.2.1. Familiarizing with data.

In qualitative research, it is very important for the researchers to recognize the data and be familiar with the context during the analysis process (Braun & Clarke, 2006). In order to ensure data immersion, it is recommended that both the data collection and the data transcription process be done by the researcher himself (Çelik, Başer Baykal, & Kılıç Memur, 2020). Therefore, the researcher took part in all data collection procedures. In addition, the researcher organized data by grouping observation notes taken in the classroom and the students' diaries on a weekly basis. Afterwards, the researcher transcribed and bring together all data obtained from the observation notes, students' diaries, and semi-structured interview records, by converting them to computer documents (Creswell, 2013). After transferring all the data to the computer documents, the researcher carefully read the whole data several times.

3.13.2.2. Generating initial codes.

Before starting to generate the initial codes, the researcher prepared a starting list of what is generally mentioned in the qualitative data content. After the first list of ideas was prepared, the researcher started to create the codes by determining the information

and concepts that were meaningful to him about the subject he studied. Since both deductive and inductive analysis are used in data analysis, in the initial coding phase, firstly, data-driven coding was conducted, then the data were coded according to the literature, and they were aggregated in a code book. Afterwards, the code book, definitions and examples of the codes, and data document were shared with another researcher in the field of educational sciences, who had knowledge and experience about qualitative research and conducted this approach in her doctoral dissertation. Two researchers discussed on the codes, similarities and differences between their thoughts, and revised the code book.

O'Connor and Joffe (2020) stated that a minimum 10% of all data should be encoded by the second encoder. Accordingly, the second coder randomly coded the data from each qualitative data type (observation, interview and students' diaries). The inter-coder reliability (ICR) ratio was calculated based on the coding made by both encoders, using the formula proposed by Miles and Huberman (1994):

$$\text{reliability} = \frac{\text{number of agreements}}{\text{number of agreements} + \text{disagreement}}$$

As a result, it was determined that there was 83% agreement between the two encoders. Since it was stated that the ICR with a rate of 80% and above was sufficient (Miles & Huberman, 1994), the study was continued with this code list.

3.13.2.3. Searching for themes.

In this step, the researcher aimed to group the codes under possible themes by reanalyzing them. Themes consist of codes that have similar properties and reflect a main idea in qualitative data analysis (Creswell, 2013). While combining different codes under possible themes, thematic maps were used (Braun & Clarke, 2006). In this step, the definitions and grouping the basic principles of Flow Theory as antecedents and outcomes made by Csikszentmihalyi, Latter and Duranso (2017) were used in the determining of codes and themes.

3.13.2.4. Reviewing themes.

At this stage, the researcher re-examined the identified possible themes and decided that some themes should be combined, and some should be included as sub-themes under other themes. This procedure allows the researcher to organize and simplify the themes and codes to be analyzed. Some data that do not belong to any theme were removed from the analysis (Braun & Clarke, 2006). According to Miles and Huberman (1994), data reduction contributes to the emergence of research results by sharpening, extracting, and organizing data. The researcher continued to review the themes until he arrived at a satisfactory thematic map that reflected the dataset.

3.13.2.5. Defining and naming themes.

In this step, the researcher defined which dimension of the data set each theme and sub-themes reflected. Then, short, concise, remarkable and understandable names for these themes were determined. In addition, it was checked whether the themes and sub-themes overlap each other, and the data represented by the themes were analyzed (Braun & Clarke, 2006). Based on Miles and Huberman's (1994) view that each theme should be homogeneous in itself and other themes need to be separate from each other, this situation was checked for all themes and sub-themes.

3.13.2.6. Producing the report.

In the last step, the researcher completed the final analysis and reported the results. The determined themes and sub-themes were explained in a clear, understandable and consistent manner. In the report, direct quotations are included in order to reveal the evidence regarding the themes. In the reporting of the findings, quotations of the students at different levels of achievement and results obtained from different data sources were included.

3.14. Internal Validity

The internal validity indicates that any relationship observed between several variables need to be clear as to what it means rather than being due to something else (Fraenkel & Wallen, 2006). Possible threats to internal validity and possible precautions for them

will be mentioned briefly. In terms of the design for this study, possible threats can be subjects' characteristics, mortality, location, history, data collector characteristics, data collector bias, and implementation.

Subject characteristics threat refers that the selection of people for a study may result in the individuals differing from one another in unintended ways that are related to the variables to be studied (Fraenkel & Wallen, 2006). In this study, participants' previous achievement, and motivation in mathematics can be the variables which can affect the results. Therefore, the researcher compared the students' pretest scores of the scales and achievement test, in order to decide whether the control and experimental groups differ significantly.

Loss of subjects means that "for one reason or another such as illness, family relocation etc. some individuals may drop out of the study. The best solution to the problem of mortality is to do one's best to prevent or minimize the loss of subjects" (Fraenkel & Wallen, 2006). However, the mortality is said to be the most difficult threat to control. Since all participants completed the process without any lost, this threat was controlled.

Location threat occurs if the particular locations where data are collected create alternative explanations for the results (Fraenkel & Wallen, 2006). However, in this study, data was collected in the same school environment and similar classrooms.

Similarly, history refers to events that happen during the course of the study that can influence the results (Fraenkel & Wallen, 2006). Since all of the data collection tools was administered to the groups at the same time, this threat was able to controlled by the researcher.

In this study, while data were collected from the students in the experimental and control groups, the researcher took part in the classroom, observed the data collection conditions and procedures. Hence, threats such as data collector characteristics and data collector bias were controlled in this way.

Implementation threat may occur when different individuals are assigned to implement different methods, or when some individuals have a personal bias in favor of one

method over the other (Fraenkel & Wallen, 2006). In this study, both experimental and control groups was taught by the same teacher and the teacher was trained before the implementation, which might help to control this threat.

3.15. Trustworthiness

In qualitative research, validity is defined as the researcher's observation of the phenomenon he is examining as it is and as unbiased as possible (Kirk & Miller, 1986). In qualitative research, some additional methods are used to confirm the data obtained and the related results in order to form a holistic picture about a phenomenon (Yıldırım & Şimşek, 2011). Lincoln and Guba (1985) suggested credibility, transferability, dependability, and confirmability strategies to increase *trustworthiness* of a qualitative research.

In the current study, some of the strategies applied to ensure *credibility* are long-term interaction with the subjects of the study, in-depth data collection, triangulation, expert review, and member checking. First of all, the researcher was in the classroom environment from the pilot application before the experimental process begins until the end of the study and observed all the teaching activities carried out. Providing long-term interaction with data sources and extending the data collection process over a long period of time in parallel with the study strengthened the credibility of the research data. In this way, the *initial effect* of the researcher on the students and the environment was reduced, by increasing the time spent in the observed environment (Yıldırım & Şimşek, 2011).

The researcher, who made observations in the classroom throughout the study, had the chance to make sense of the events and phenomena in terms of the research question and to reveal the relationships as a whole. In addition, the study included both method triangulation and researcher triangulation, since different data collection tools such as observation, interview, student diaries, achievement test and other scales were used, and there was a second encoder (Creswell, 2015). In the process of analyzing the data obtained in the study, opinions and feedback were received from an experienced expert in qualitative research at all steps from the generating the initial codes to the reporting of the results. Finally, right after the interviews, the researcher shared a summary of

the interview with the interviewees for the member checking, in line with the data he collected and asked whether they were understood correctly or not (Erlandson, Harris, Skipper, & Allen, 1993; Maxwell, 1996). The participants had the opportunity to express the thoughts they wanted to add or correct in this way (Yıldırım & Şimşek, 2011).

Another strategy used to ensure the trustworthiness of the research is *transferability*. Erlandson et al. (1993) recommend two methods for ensuring the transferability. Accordingly, the researcher described the participants, setting and obtained data in detail and conveyed the codes and themes that emerged without adding comments. Thus, the trustworthiness of the results was increased by presenting direct quotations for the codes obtained (Yıldırım & Şimşek, 2011). In addition, the use of purposive sampling methods in determining the participants with whom the interviews will be conducted is considered important in terms of transferability (Maxwell, 1996).

Measures that can be taken to ensure *dependability* include keeping the raw data of the research and recording the interviews to prevent data loss (Maxwell, 1996). Additionally, the researcher was as consistent as possible at all stages of the study, such as the preparation of data collection tools, collection of data, analysis and interpretation. For this reason, the researcher himself took part in the classroom during the quantitative data collection process and made the necessary explanations to the experimental and control group students. In addition, in the process of obtaining qualitative data, attention was paid to processes such as asking all interview questions in a similar way to the interviewees and focusing on similar points by using the observation frame. Moreover, the researcher identified each step in the study clearly, presented a sample lesson plan in the appendix for other researchers who might apply in other school settings, in order to enhance the dependability of the results. Explanations such as what the teacher should pay attention to in Flow Theory-based mathematics teaching and its role in the classroom, how communication between students and learner control should be provided are presented in detail in the study. Hence, the other researchers can apply similar studies in different context (Erlandson et al., 1993).

Finally, in order to ensure confirmability, the researcher continuously confirmed the results obtained from the data analysis with the collected data, providing the reader with a logical explanation without any bias (Yıldırım & Şimşek, 2011). Additionally, the role of the researcher was defined in the research. Literature related to the data is presented in the research report.

3.15. The Role of the Researcher

As it can be understood from the above-mentioned issues about how measures are taken regarding the validity and reliability threats of the research, it is thought that the researcher's position, competencies, personal values, assumptions, and prejudices throughout the process are especially important in terms of reliability. For this reason, it would be appropriate to explain how the researcher undertakes in the process from the planning of the research to the end of reporting.

The researcher completed his undergraduate education in the field of Elementary Mathematics Education department and received his master's degree in the field of Curriculum and Instruction. In this study, a deep literature review was made about the Flow Theory and RME approaches used in the design of the instruction. Afterwards, an eleven-week instructional design based on these approaches was prepared for the fifth-grade mathematics course by the researcher. The researcher informed the teacher, who implemented the instructional design, about the principles of Flow Theory, implementation of RME, the points to be considered in the application of these principles, the studies about Flow Theory, the classroom environment in instruction based on Flow Theory and RME, the roles of students and teacher, the characteristics of teaching activities and materials to be used, and some details of the experimental study to be carried out. Additionally, the Mathematics Test applied to determine mathematics achievement and retention of the fifth-grade students, interview form and observation frame were also prepared by the researcher.

In addition, the researcher has taken part in the trial application of the mathematics instruction for two weeks, before the experimental process started. During the study, the researcher followed the mathematics lessons as a non-participant observer and observed the teaching activities carried out in the classroom using the observation form

and taking notes. Pretest, posttest, and retention test applications of quantitative data collection tools to the experimental and control groups were conducted by the researcher. In addition, semi-structured interviews with ten students from the experimental group were conducted and recorded by the researcher. It can be said that the participants were quite comfortable while collecting data about the process and conducting interviews at the end of the process. This is important to ensure that they respond honestly and sincerely to the questions posed to them. One of the main reasons for this might be that the researcher has been involved in the teaching environment from the very beginning.

Finally, the researcher analyzed all the quantitative and qualitative data, and reported results. Especially when reporting qualitative findings, tables are given to show from which data source the data were obtained, and frequency values are presented separately for each data source. The researcher kept all the raw data he obtained to resolve ethical issues. These raw data include the diaries kept by the students in their own handwriting, the observation notes made during the lesson, the audio recordings of the interviews, and the documents of the quantitative data.

3.16. Limitations

1. This study was limited to fifth-grade students in a state elementary school in İzmir province, during the spring semester of the 2017-2018 academic year. As the sample size was limited with two classrooms with 73 students, the results cannot be generalized to other contexts.
2. The data was collected only from two learning areas (Numbers and Operations, Geometry and Measurement) which included five topics (Percentages, Basic Geometric Concepts and Drawings, Triangles and Quadrilaterals, Measurement of Length and Time, Measurement of Area).
3. The students in either control or experimental group may not respond to the measurement tools sincerely and honestly.
4. The principles of Flow Theory, the characteristics of the instruction designed based on Flow Theory principles and RME were shared with the teacher in detail. Even

so, it could be a possibility that the teacher did not understand the theory sufficiently.

5. In the experimental group, students participated group work for the first time. Although there was a two-week adaptation practice for the students, they might have felt uncomfortable during the activities since they were not accustomed to such instruction.
6. Teaching in the experimental and control groups was carried out by the same teacher. Although the teacher was reminded before the experiment that there should be as little interaction as possible between the experimental and control groups and that she should not mention the teaching in the experimental group in the control group, the teacher might still have transferred the experience she had in the experimental group to the other group.

CHAPTER IV

RESULTS

The purpose of the study was to investigate the effects of the instruction designed based on Flow Theory principles on elementary fifth grade students' mathematics achievement, retention, flow states in mathematics course, and motivation towards mathematics; and to explore the opinions of students about the instruction. According to the research questions, this chapter will cover firstly quantitative results which were obtained from Mathematics Test (MT), Flow State Scale (FSS) and Mathematics Motivation Scale (MMS) respectively; then qualitative results which were obtained from semi-structured interviews, classroom observations and student diaries about the instruction.

4.1. The Results About the Effect of Instruction on Mathematics Achievement and Retention

The purpose of the first research question was to investigate whether there exists a significant difference between the immediate and retained Mathematics Test scores of the experimental and control group students.

The descriptive statistics of the pretest, posttest and retention test scores of the MT were presented in Table 4.1 below.

Table 4.1

Descriptive Statistics of Pretest, Posttest and Retention Test in Mathematics

Groups	Time	<i>N</i>	<i>M</i>	<i>SD</i>	Min.	Max.	Range	Skew.	Kurtosis
Experimental Group	Pretest	37	39.34	15.29	5.56	77.78	72.22	.375	.614
	Posttest	37	64.56	19.39	27.78	100.00	72.22	.087	-.755
	Retention	37	68.62	19.52	33.33	100.00	66.67	-.074	-.904
Control Group	Pretest	36	38.43	17.03	5.56	77.78	72.22	.411	-.013
	Posttest	36	61.11	21.25	16.67	100.00	83.33	-.117	-.752
	Retention	36	58.64	19.81	22.22	94.44	72.22	-.029	-.728

According to Table 4.1, the minimum scores received by the experimental group were 5.56 for the pretest, 27.78 for the posttest, and 33.33 for the retention test. Similarly, the minimum scores received by the control group were 5.56 for the pretest, 16.67 for the posttest, and 22.22 for the retention test. While the maximum scores of the experimental group from the pretest, posttest and follow-up test were 77.78, 100.00 and 100.00, respectively, these scores for the control group were 77.78, 100.00 and 94.44, respectively.

In order to demonstrate the location and distribution of the MT scores, the boxplot was used. The box represents the middle 50% (those between 25th and 75th percentiles) of the cases (Morgan, Leech, Gloeckner & Barret, 2007). The maximum scores in both experimental and control group were higher than the median score. The range of the experimental group means for the pretest was the same as that of the control group. The posttest mean scores were slightly higher in the experimental group comparing to the control group. While the range of the posttest scores of the experimental group remained the same, the range of the posttest scores of the control group increased. Comparing the posttest scores, the range of the retention test scores decreased for both experimental and control groups. Figure 4.1. demonstrates the clustered boxplot of the PREMAT, POSTMAT and RETMAT for the experimental and control groups.

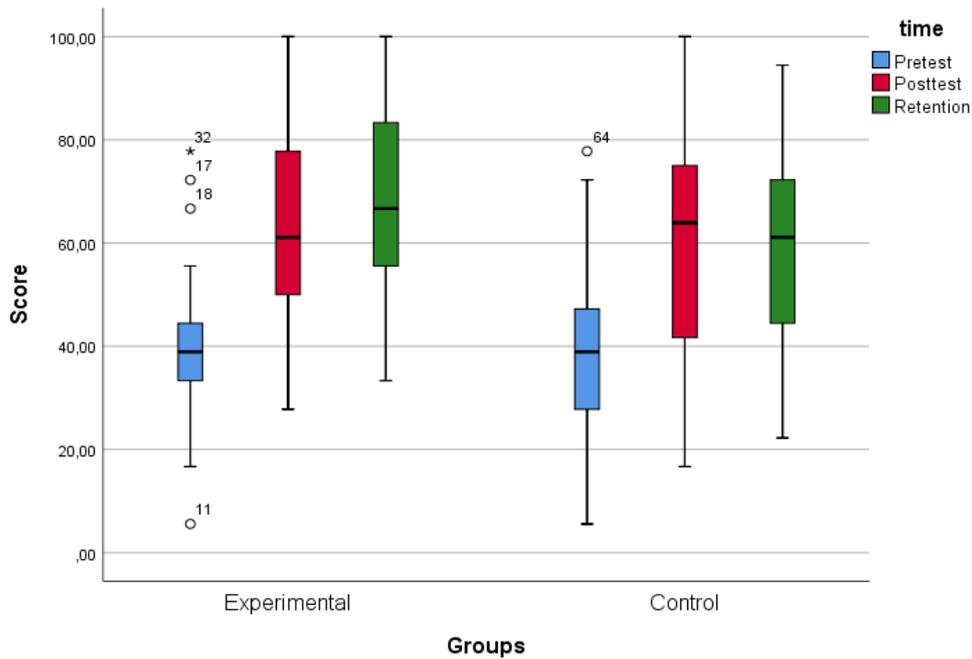


Figure 4.1. Boxplot of PREMAT, POSTMAT and RETMAT.

A Mixed Between-Within Subjects of ANOVA with Repeated Measures was conducted to the Mathematics Test scores of the experimental and control group students in order to examine whether there were group and time differences in the MAT scores.

Before conducting the mixed ANOVA, the assumptions which consisted of normal distribution of the dependent variables, equality of error variances and equivalence of population covariance matrices were tested for the mathematics scores. Since the dependent data comprise the *within subjects* or *repeated measures* factor, the independence of observations assumption was ignored (Leech, et al., 2008).

Normal distribution of the dependent variables: In order to check the normality assumption, Skewness and Kurtosis values, histograms, Q-Q plots, Kolmogorov-Smirnov and Shapiro-Wilk tests were taken into consideration (Field, 2013). As seen in Table 4.1, the skewness and kurtosis values of both experimental and control group were between -1 and +1 for all three mathematics test scores (pre-, post- and retention

test). Q-Q plots also showed the normality of distributions as the plots were around the line, and they were not scattered too much from the line. Moreover, visually the distributions were seen approximately normal from the histograms. Finally, the results of the Kolmogorov-Smirnov and Shapiro-Wilk tests were non-significant for both experimental and control groups on post- and retention scores, but for the pretest scores only Shapiro-Wilk tests showed non-significant results. As Field (2013) stated that this result could be affected by sample size. However, Shapiro, Wilk and Chen (1968) investigated that with sample sizes between 10 to 50, the combination of skewness and kurtosis coefficients and the test of Shapiro-Wilk had the most powerful detection of departures from normality. Hence, it can be said that data showed normal distribution for both groups on three achievement tests.

The assumption of sphericity: The sphericity assumption must hold for levels of the within subjects variable at each level of between subjects variables. This assumption was tested using SPSS with Mauchly's test. The test result indicated that the assumption of sphericity had been violated for the main effect of time, $W = .688$, $\chi^2(2) = 26.21$, $p < .001$. Therefore, degrees of freedom was corrected using Greenhouse-Geisser estimates of sphericity, $\epsilon = .76$ for the main effect of time (Tabachnick & Fidell, 2013).

Homogeneity of variance-covariance matrices: This assumption was tested using Box's M statistic. It should be accepted as indicating a problem only if it shows a significant departure from homogeneity at $p = .001$ or less (Tolmie, Muijs & McAteer, 2011). Since Box's M returned a p -value that is more than .001, there are no significant differences between variance-covariance matrices. Hence, the assumption is not violated.

Table 4.2 presents the results for the first research problem which indicates the change between the pretest, posttest and retention test of mathematics scores of experimental and control groups, taking time into consideration.

Table 4.2

ANOVA Results for PREMAT, POSTMAT and RETMAT Scores

Source	SS	df	MS	F	p	η^2
Between Subjects						
Group	1251.328	1	1251.328	1.422	.237	.020
Error	62478.026	71	879.972			
Within Subjects						
Time (PREMAT, POSTMAT and RETMAT)	28876.464	1.524	18947.828	159.206	.000	.692
Group*Time	797.655	1.524	523.396	4.398	.023	.058
Error (Time)	12877.862	108.204	119.015			

Results of mixed ANOVA indicated a significant main effect of time, $F(1.524, 108.204) = 159.206, p = .000$. According to Cohen (1988), this effect was much larger than typical $\eta^2 = .69$, since the indicators were defined as if $\eta^2 > .010$ the effect is small or smaller than typical, if $\eta^2 > .057$ the effect is medium or typical, if $\eta^2 > .136$ the effect is large or larger than typical, if $\eta^2 > .202$ the effect is much larger than typical (Cohen, 1988; Leech et al., 2008: p.81). However, results of Mixed ANOVA indicated that the main effect for group was statistically non-significant $F(1, 71) = 1.422, p = .24$. Moreover, the results of mixed ANOVA indicated that group interacted in some way with the three different testing times of mathematics. There was a significant interaction between the time of the test and the group of the subjects, $F(1.524, 108.204) = 4.398, p < .05$. According to Cohen (1988), this effect was medium or typical as $\eta^2 = .058$. This effect tells us that scores of subjects in three different testing times (pre-, post- and retention test) were different for experimental and control groups.

As the main effect of time was found significant, there was a need to examine the underlying factors of this difference. Table 4.3 shows the pairwise comparisons for the main effect of time corrected using a Bonferroni adjustment.

Table 4.3

Pairwise Comparisons for the Main Effect of Time

Group	Time	Time	Mean Difference	SE	Sig.
Experimental Group	PREMAT	POSTMAT	-25,225*	2,409	,000
		RETMAT	-29,279*	2,587	,000
	POSTMAT	PREMAT	25,225*	2,409	,000
		RETMAT	-4,054*	1,487	,024
	RETMAT	PREMAT	29,279*	2,587	,000
		POSTMAT	4,054*	1,487	,024
Control Group	PREMAT	POSTMAT	-22,685*	2,442	,000
		RETMAT	-20,216*	2,623	,000
	POSTMAT	PREMAT	22,685*	2,442	,000
		RETMAT	2,469	1,507	,318
	RETMAT	PREMAT	20,216*	2,623	,000
		POSTMAT	-2,469	1,507	,318

According to Table 4.3, the significant main effect of time reflects for the experimental group that the difference between the pretest and posttest ($p < .001$); posttest and retention test ($p < .05$); and pretest and retention test ($p < .001$) mathematics scores were statistically significant. In addition, the significant main effect of time reflects for the control group that the difference between the pretest and posttest ($p < .001$); pretest and retention test ($p < .001$) mathematics scores were also significant. However, there was no significant difference between posttest and retention test ($p > .05$) mathematics scores of control group. This seems to indicate that Flow Theory-based instruction had an effect on mathematics scores of experimental group on

posttest and retention test; but instruction applied in control group had significant effect only on posttest mathematics scores. The mean scores of the experimental and control groups across three testing times (pre-, post- and retention test) can be seen in the Figure 4.2 below.

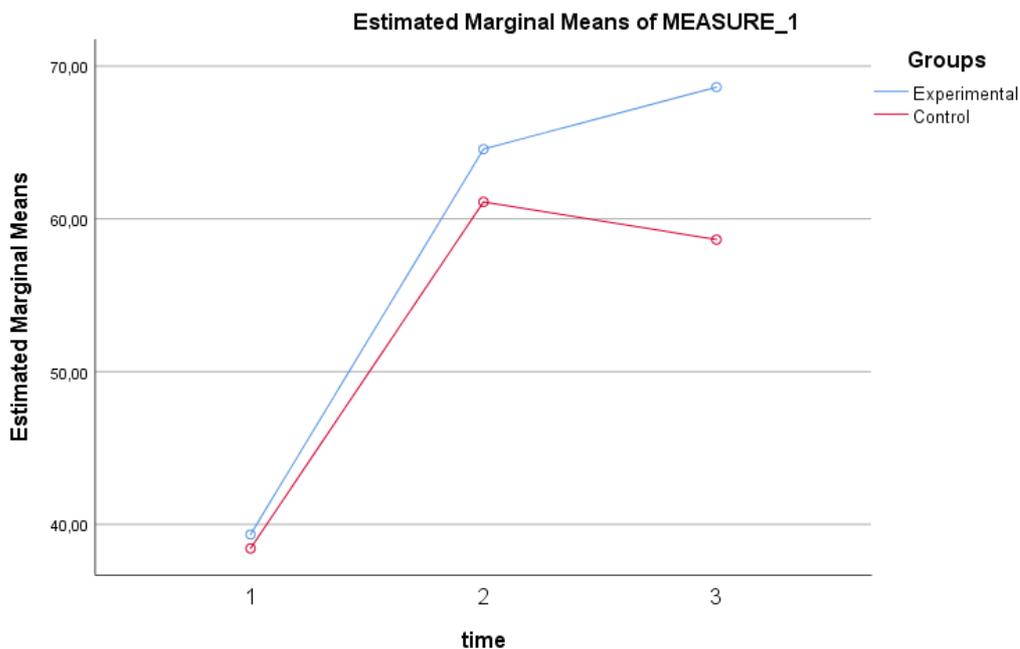


Figure 4.2. PREMAT, POSTMAT and RETMAT scores of the groups.

According to the Figure 4.2, the experimental and control group have very similar scores on the pretest. Both groups increased their mathematics scores substantially from pretest to posttest, but experimental group increased their posttest scores slightly more than the control group. However, the experimental group continued to increase their scores in the retention test albeit with less slope, while the control group decreased minimally its score on retention test. This interaction can be clarified using the contrasts specified before the analysis:

The first interaction term looks at PREMAT and POSTMAT, comparing the scores of experimental and control groups. This contrast is non-significant, $F(1,71) = .548, p > .05$, which indicates that the scores taken from POSTMAT compared to PREMAT by

the experimental group students did not significantly differ from the control group students' scores.

The second interaction term looks at POSTMAT and RETMAT, comparing the scores of experimental and control groups. This contrast is significant, $F(1,71) = 9.491, p < .05$, which indicates that the scores taken from RETMAT compared to POSTMAT by the experimental group are significantly higher than the scores of the control group. As seen in the Figure 4.2, the direction of the line between the POSTMAT and RETMAT of the two groups are different. It can be concluded that the mathematics retention test scores (RETMAT) compared to posttest scores (POSTMAT) are greater for the experimental group than the control group.

4.2. The Results About the Effect of Instruction on Flow State in Mathematics

The purpose of the second research question was to investigate whether there exists a significant difference between the immediate Flow State Scale (FSS) scores of the experimental and control group students. The scores related to subdimensions Flow (FSD), Boredom (BSD) and Anxiety (ASD) were analyzed separately.

A 2 (Time) x 2 (Group) Mixed Between-Within Subjects of ANOVA with Repeated Measures (Split-Plot ANOVA) was conducted to the subdimensions of Flow State Scale scores of the experimental and control group students in order to examine whether there were group and time differences between the (FSS) scores.

Before conducting the mixed ANOVAs, the assumptions which consisted of normal distribution of the dependent variables, equality of error variances and equivalence of population covariance matrices were tested for the FSS scores. Since the dependent data comprise the within subjects or repeated measures factor, the independence of observations assumption was ignored (Leech et al., 2008).

Normal distribution of the dependent variables: In order to check the normality assumption for all subdimensions (flow, boredom and anxiety), the Skewness and Kurtosis values, Kolmogorov-Smirnov and Shapiro-Wilk tests, histograms and Q-Q plots, were taken into consideration separately (Field, 2013).

The assumption of sphericity: The sphericity assumption must hold for levels of the within subjects variable at each level of between subjects variables. However, for the 2x2 mixed ANOVA, since there is only one pair of levels for a within-subjects factor, the sphericity assumption was not violated (Leech, Barrett & Morgan, 2008). Therefore, there is no need to check the sphericity assumption in these analyses (Tabachnick & Fidell, 2013).

Homogeneity of variance-covariance matrices: This assumption was tested using Box’s M statistic, for all subdimensions separately. It should be accepted as indicating a problem only if it shows a significant departure from homogeneity at $p = .001$ or less (Tolmie, Muijs, & McAteer, 2011).

4.2.1. The results about the effect of instruction on flow subdimension.

The research problem 2-a investigated whether there is a significant difference between Posttest Flow Subdimension scores of the experimental and control group students. The descriptive statistics of the pretest and posttest scores of FSD were provided in Table 4.4 below.

Table 4.4

Descriptive Statistics of the FSD Scores on Pretest and Posttest

Groups	Time	<i>N</i>	<i>M</i>	<i>SD</i>	Min.	Max.	Range	Skewness	Kurtosis
Experimental	PREFSD	37	16.05	2.15	12.00	20.00	8.0	.104	-.764
	POSTFSD	37	17.65	2.25	13.00	20.00	7.0	-.600	-.875
Control	PREFSD	36	15.67	2.34	10.00	20.00	10.0	-.350	-.109
	POSTFSD	36	16.31	2.68	10.00	20.00	10.0	-.525	-.373

According to Table 4.4, the minimum scores received by the experimental group were 12 for the pretest, 13 for the posttest, while maximum scores were 20 for both testing time. For the control group, the minimum scores from the pretest and posttest were 10, while the maximum scores were 20. The cut-off point for the Flow subdimension was

determined as 10 points (out of 20 points) by the researchers who developed the Flow State Scale based on the 4-scale rating (Eryilmaz & Mammadov, 2016a). Therefore, since the pretest ($M_E = 16.05$) and posttest ($M_E = 17.65$) scores of the experimental group were above the cut-off point, it was interpreted as a high level of Flow. Similarly, the Flow Subdimension scores of control group on pretest ($M_C = 15.67$) and posttest ($M_C = 16.31$) were also above the cut-off point, which interpreted as high-level of Flow.

In order to represent the location and distribution of the FSD scores, the clustered boxplot was used. The box represents the middle 50% (those between 25th and 75th percentiles) of the cases (Morgan et al., 2007). The maximum scores in both experimental and control group were higher than the median score. The range of the pretest scores were lower in experimental group compared to control group. The posttest mean score was slightly higher in experimental group compared to control group. The range of the posttest scores decreased compared to pretest scores in experimental group, while in control group the range increased from pretest to posttest.

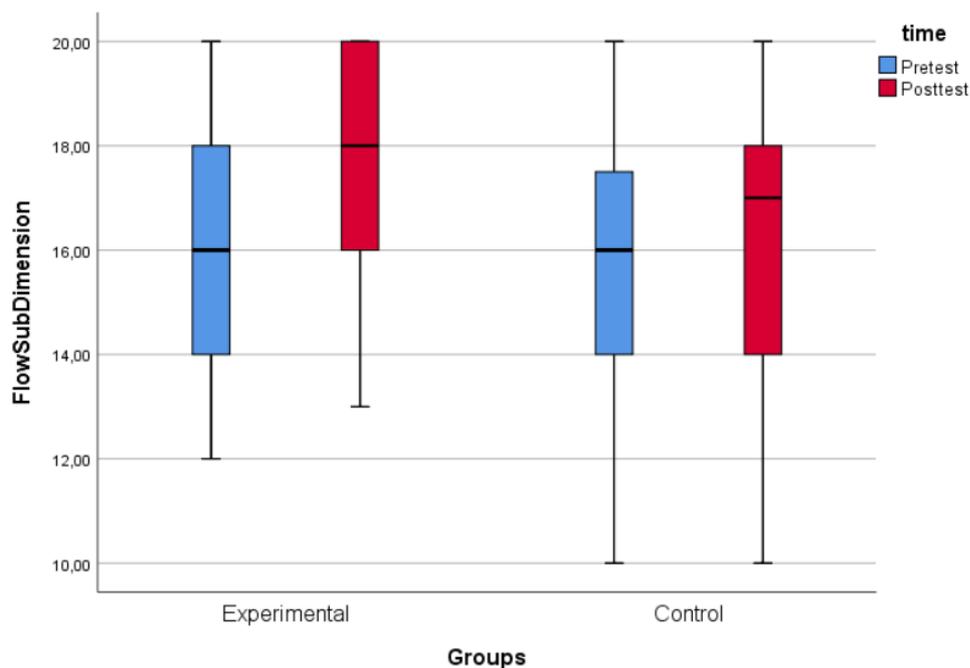


Figure 4.3. Boxplot for the PREFSD and POSTFSD.

Normality Test for Flow Subdimension: The Skewness and Kurtosis values of both experimental and control groups were between -1 and +1 for both pretest and posttest FSD scores (see Table 4.4). However, for the pretest scores of both experimental and control groups, the results of the Kolmogorov-Smirnov and Shapiro-Wilk tests were non-significant, while for the posttests, only the values for the control group were non-significant. As Field (2013) stated that these results could be affected by sample size. Q-Q plots showed the normality of distributions as the plots were around the line, and they were not scattered too much from the line. In addition, the distributions were considered close to normal according to histograms.

The Test of Sphericity for Flow Subdimension: Since there are two levels of the repeated measure variable (time), Maucly's test can not be calculated. However, the assumption of sphericity is not a problem when there is only one pair of levels (Leech, Barrett & Morgan, 2008).

The Test of Homogeneity of Variance-Covariance Matrices for Flow Subdimension: Since Box's M returned a p -value that is more than .001, there are no significant differences between variance-covariance matrices (Tolmie, Muijs & McAteer, 2011). Hence, the assumption was met for the Flow subdimension.

Table 4.5 presents the results of the second research problem which indicates the change between the pretest and posttest scores for Flow Subdimension of experimental and control group students, taking time into consideration. Accordingly, results of Mixed ANOVA indicated that there was a significant main effect of time, $F(1, 71) = 19.39, p = .000$. According to Cohen (1988), this effect was much larger than typical since $\eta^2 = .22$. This effect tells us that if we ignore the group of participants, some types of testing time were still rated significantly differently to others. In other words, this result shows that the experimental process has a significant effect on the increase in students' FSD scores. In addition, the results of Mixed ANOVA indicated that the main effect for group was not statistically significant, $F(1, 71) = 3.10, p = .083, \eta^2 = .04$. The results also indicated that there was not a statistically significant interaction between group and time, $F(1, 71) = 3.55, p = .064, \eta^2 = .05$.

Table 4.5

ANOVA Results for PREFSD and POSTFSD Scores

Source	SS	<i>df</i>	MS	<i>F</i>	<i>p</i>	η^2
Between Subjects						
Group	13.66	1	13.66	3.10	.083	.04
Error	312.68	71	4.40			
Within Subjects						
Time (PREFSD and POSTFSD)	45.51	1	45.51	19.39	.000	.22
Group*Time	8.33	1	8.33	3.55	.064	.05
Error (Time)	166.61	71	2.35			

As the main effect of time was found significant, there was a need to examine the underlying factors of this difference. Hence, independent samples *t*-test was used to examine whether there was a difference between the posttest scores of the experimental and control groups, and the paired samples *t*-test was conducted to determine whether within-group scores of experimental and control groups on pretest and posttest significantly differed. Table 4.6 and Table 4.7 show the results of *t* tests within and between the groups.

Table 4.6

t-Test Results Comparing the Groups on POSTFSD Scores

Variable	Group	<i>N</i>	<i>M</i>	<i>SD</i>	<i>t</i>	<i>df</i>	<i>p</i>
POSTFSD	Experimental	37	17.65	2.25	2.32	71	.023
	Control	36	16.31	2.68			

As seen in Table 4.6, although the effect size is small according to Cohen's (1988) guidelines ($d = .22$), there is a significant difference between the posttest Flow Subdimension scores of the experimental and control groups, in favor of the experimental group $t(71) = 2.32, p < .05$.

Table 4.7

t-Test Results Comparing PREFSD and POSTFSD Scores of Groups

Group	Variable	<i>N</i>	<i>M</i>	<i>SD</i>	<i>t</i>	<i>df</i>	<i>p</i>
Experimental	PREFSD	37	16.05	2.15	5.17	36	.000
	POSTFSD		17.65	2.25			
Control	PREFSD	36	15.67	2.34	1.58	35	.123
	POSTFSD		16.31	2.68			

Additionally, as presented in Table 4.7, paired samples *t*-test indicated that experimental group students had on average significantly higher Flow Subdimension scores on posttest than pretest, $t(36) = 5.17, p = .000$. The effect size ($d = .84$) which is computed by dividing the mean of the paired differences by the standard deviation of the paired differences can be interpreted as *large or larger than typical*, according to Cohen's (1988) guidelines. However, the scores of control group on pretest and posttest Flow Subdimension were not significantly differed, $t(35) = 1.58, p > .05$. This seems to indicate that instruction applied in experimental group had an effect on increasing the FSD scores of experimental group on posttest, but instruction applied in control group did not have any significant effect on FSD scores of control group on posttest.

When the findings in Table 4.6 and Table 4.7 are considered together, it can be interpreted that the source of the significant difference in time main effect obtained in 2x2 mixed ANOVA is that the students in the experimental group had significantly

higher scores in the posttest than both their own pretest scores, and the posttest scores of the students in the control group. In addition, the significance value of the group and time interaction obtained as a result of mixed ANOVA should be treated with caution as the significance level is so close to the $p = .05$ value. Since this value is very close to $p = .05$, these values are considered as marginally significant in many studies in the literature (Pritschet, Powell, & Horne, 2016). One of the most important factors in obtaining such a result could be that the sample size is not large enough. With a sufficiently large sample size, this statistical test would show a significant difference (Sullivan & Feinn, 2012), even when the difference is very small/weak (Morgan et al., 2007). The mean scores of the experimental and control group across two testing times (pretest and posttest) are shown in the Figure 4.4 below.

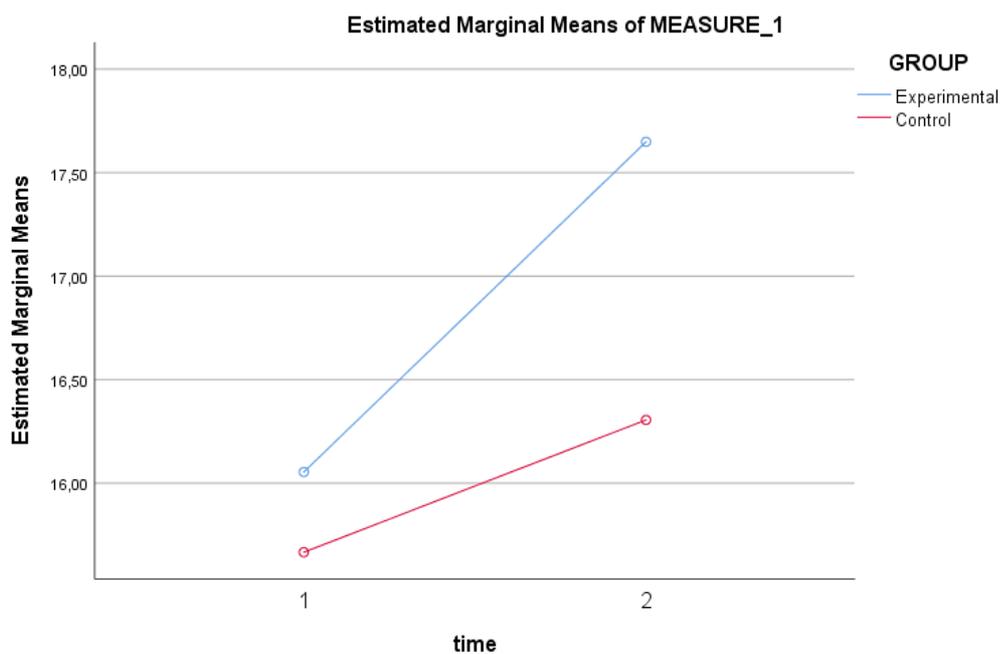


Figure 4.4. PREFSD and POSTFSD scores of the groups.

According to Figure 4.4, the experimental and control groups had similar scores on the pretest ($M_E = 16.05$, $M_C = 15.67$). In the posttest, although both groups increased their

scores, the experimental group students increased their scores more substantially than the control group ($M_E = 17.65$, $M_C = 16.31$).

4.2.2. The results about the effect of instruction on the boredom subdimension.

The research question 2-b investigated whether there is a significant difference between boredom subdimension posttest scores of experimental and control group students. The descriptive statistics of the pretest and posttest of Flow State Scale for the boredom subdimension (BSD) were provided in Table 4.8 below. The cut-off point for the Boredom Subdimension was determined as 8 points (out of 16 points) by the researchers who developed the Flow State Scale based on the scale rating (Eryılmaz & Mammadov, 2016a). Therefore, since the pretest scores of the experimental group ($M_E = 7.11$) were below the cut-off point, it was interpreted as a low level of Boredom. Similarly, the posttest ($M_E = 6.22$) scores of the experimental group were found below the cut-off point. The scores of control group on pretest ($M_C = 7.03$) and posttest ($M_C = 6.72$) BSD were also below the cut-off point, which interpreted as a low-level of Boredom.

Table 4.8

Descriptive Statistics of the BSD Scores on Pretest and Posttest

Groups	Time	<i>N</i>	<i>M</i>	<i>SD</i>	Min.	Max.	Range	Skewness	Kurtosis
Experimental Group	PREBSD	37	7.11	1.91	4.00	12.00	8.00	.342	.133
	POSTBSD	37	6.22	2.03	4.00	11.00	7.00	.616	-.612
Control Group	PREBSD	36	7.03	2.27	4.00	12.00	8.00	.458	-.392
	POSTBSD	36	6.72	2.25	4.00	12.00	8.00	.415	-.646

According to Table 4.8, the minimum scores received by both experimental and control groups were 4 for both pretest and posttest. Additionally, while the maximum

scores received by the experimental group was 12 for the pretest, and 11 for the posttest, while the control group's maximum scores were 12 for both testing time.

In order to represent the location and distribution of the BSD scores, the clustered boxplot was used. The box represents the middle 50% (those between 25th and 75th percentiles) of the cases (Morgan, Leech, Gloeckner & Barret, 2004). The maximum scores in both experimental and control group were higher than the median score. The range of the experimental group means for the pretest was similar with that of control group. The posttest mean score was slightly lower in the experimental group compared to control group. The range of the posttest scores decreased compared to the pretest scores in experimental group, while in the control group the range remained the same for the posttest and the pretest scores. Figure 4.5 demonstrates the clustered boxplot of the PREBSD and POSTBSD scores of the pretest and posttest for the experimental and control groups.

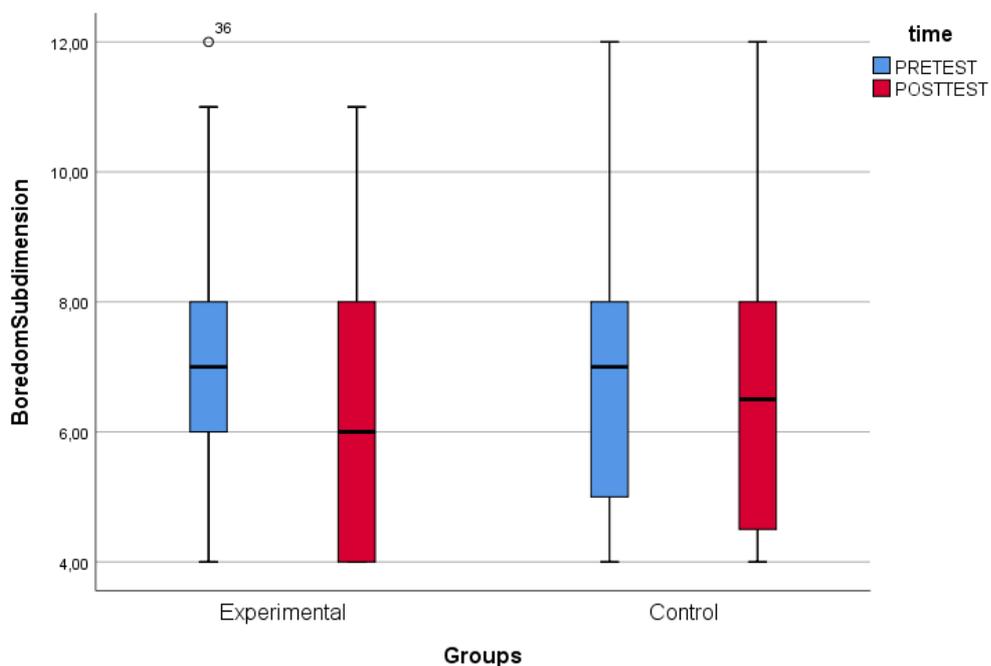


Figure 4.5. Boxplot for the BSD scores on pretest and posttest.

Normality Test for Boredom Subdimension: The Skewness and Kurtosis values of both experimental and control groups indicated a normality since the values were between -1 and +1 for both pretest and posttest boredom subdimension scores (George & Mallery, 2020). The results of the Kolmogorov-Smirnov test were non-significant for the pretest scores of both groups and posttest scores of control group. However, the results of Shapiro-Wilk tests were non-significant only for the pretest scores of experimental group. As Field (2013) stated that these results could be affected by sample size. Q-Q plots showed the normality of distributions as the plots were around the line, and they were not scattered too much from the line. In addition, the distributions were considered close to normal according to histograms.

The Test of Sphericity for Boredom Subdimension: Since there are two levels of the repeated measure variable (time), Maucly's test cannot be calculated. However, the assumption of sphericity is not a problem when there is only one pair of levels (Leech, Barrett & Morgan, 2008). Therefore, *F*-statistics for the main effect of time (and its interaction with the between-group variable *group*) did not need to be corrected for violations of sphericity (Tabachnick & Fidell, 2013).

The Test of Homogeneity of Variance-Covariance Matrices for Boredom Subdimension: Since Box's *M* returned a *p*-value that is more than .001, there are no significant differences between variance-covariance matrices (Tolmie, Muijs, & McAteer, 2011). Hence, the assumption was met for the Boredom subdimension.

Table 4.9 represents the results of the second research problem which indicates the change between the pretest and posttest scores for Boredom subdimension of experimental and control group students taking time into consideration. Results of Mixed ANOVA indicated that there was a significant main effect of time, $F(1, 71) = 5.64, p < .05$. According to Cohen's (1988) guidelines this effect size can be considered as *medium or typical* since $\eta^2 = .074$. This effect tells us that if we ignore the group of participants, some types of testing time were still rated significantly differently to others. However, the mixed ANOVA results indicated that there was a non-significant main effect of group $F(1, 71) = .25, p > .05$. This effect tells us that if we ignore the testing time, experimental group's Boredom subdimension scores did

not differ from that of control group. In addition, the results also indicated that the interaction between group and time was also non-significant, $F(1,71) = 1.35, p > .05$. This result demonstrated that the boredom subdimension scores of subjects in both testing times (pretest and posttest) did not differ for the experimental and control groups.

Table 4.9

ANOVA Results for the PREBSD and POSTBSD Scores

Source	SS	df	MS	F	p	η^2
Between Subjects						
Groups	.83	1	.83	.25	.620	.003
Error	236.72	71	3.33			
Within Subjects						
Time (PREBSD and POSTBSD)	13.08	1	13.08	5.64	.020	.074
Group*Time	3.14	1	3.14	1.35	.249	.019
Error (Time)	164.60	71	2.32			

As the main effect of time was found significant, there was a need to examine the underlying factors of this difference. Since there is only one pair of levels, 2x2 mixed ANOVA cannot make pairwise comparisons for the main effect of time corrected using a Bonferroni adjustment. Therefore, the independent samples *t*-test and paired-samples *t*-tests were conducted, separately. Table 4.10 and Table 4.11 show the results of *t* tests within and between the groups.

Table 4.10

t-Test Results Comparing the Groups on POSTBSD Scores

Variable	Group	<i>N</i>	<i>M</i>	<i>SD</i>	<i>t</i>	<i>df</i>	<i>p</i>
POSTBSD	Experimental	37	6.22	2.03	1.01	71	.316
	Control	36	6.72	2.25			

According to Table 4.10, independent samples *t*-test results indicated that there was not a significant difference between experimental and control groups on posttest BSD scores, $t(71) = 1.01, p > .05$.

Table 4.11

t-Test Results Comparing PREBSD and POSTBSD Scores of the Groups

Group	Variable	<i>N</i>	<i>M</i>	<i>SD</i>	<i>t</i>	<i>df</i>	<i>p</i>
Experimental	PREBSD	37	7.11	1.91	2.63	36	.013
	POSTBSD		6.22	2.03			
Control	PREBSD	36	7.03	2.27	.82	35	.419
	POSTBSD		6.72	2.25			

According to Table 4.11, a paired samples *t*-test indicated that experimental group students had on average significantly lower Boredom subdimension scores on posttest than pretest, $t(36) = 2.63, p < .05$. The effect size ($d = .43$) which is computed by dividing the mean of the paired differences (.89) by the standard deviation of the paired differences (2.06) can be interpreted as *small or smaller than typical*, according to Cohen's (1988) guidelines. However, the scores of control group on pretest and posttest BSD were not significantly differed, $t(35) = .82, p > .05$. These results seem

to indicate that while instruction applied in experimental group had an effect on decreasing Boredom Subdimension scores of experimental group on posttest, instruction in control group did not have any significant effect on BSD scores of control group on posttest. The mean scores of the experimental and control groups across two testing times (pretest and posttest) are shown in the Figure 4.6 below.

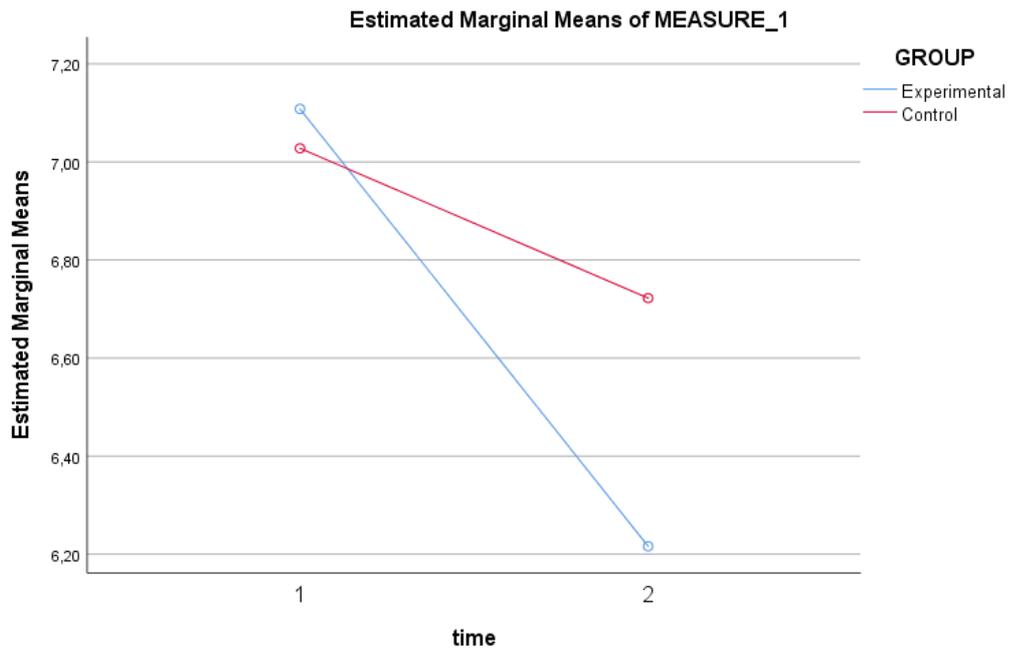


Figure 4.6. BSD scores of the groups on pretest and posttest

According to Figure 4.6, the experimental and control groups had similar scores on the pretest ($M_E = 7.11$, $M_C = 7.03$). In the posttest, although both groups decreased their BSD scores, the experimental group students decreased their scores more substantially than the control group ($M_E = 6.22$, $M_C = 6.72$).

4.2.3. The results about the effect of instruction on anxiety subdimension.

The research problem 2-c investigated whether there is a significant difference between Anxiety subdimension posttest scores of experimental and control group

students. The descriptive statistics of the pretest and posttest scores of Flow State Scale for the Anxiety subdimension (ASD) were provided in Table 4.12, below. The cut-off point for the Anxiety subdimension was determined as 8 points (out of 16 point) by the researchers who developed the Flow State Scale based on the scale rating (Eryılmaz & Mammadov, 2016a). Therefore, since the pretest scores of the experimental group ($M_E = 7.30$) were below the cut-off point, it can be interpreted as a low level of Anxiety. Similarly, the posttest ($M_E = 6.41$) scores of the experimental group were found below the cut-off point. The scores of control group on pretest ($M_C = 6.83$) and posttest ($M_C = 6.75$) ASD scores were also found below the cut-off point, which was interpreted as low-level of anxiety.

Table 4.12

Descriptive Statistics of the ASD Scores on Pretest and Posttest

Groups	Time	<i>N</i>	<i>M</i>	<i>SD</i>	Min.	Max.	Range	Skewness	Kurtosis
Experimental Group	PREASD	37	7.30	2.39	4.00	13.00	9.00	.388	-.645
	POSTASD	37	6.41	2.01	4.00	11.00	7.00	.452	-.696
Control Group	PREASD	36	6.83	2.29	4.00	12.00	8.00	.384	-.801
	POSTASD	36	6.75	2.63	4.00	14.00	10.00	.904	.298

According to Table 4.12, the minimum scores received by both experimental and control groups were 4, for both pretest and posttest. Additionally, while the maximum score received by the experimental group was 13 for the pretest, and 11 for the posttest, while the control group's maximum scores were 12 for the pretest, and 14 for the posttest.

In order to represent the location and distribution of the ASD scores, the clustered boxplot was used. The box represents the middle 50% (those between 25th and 75th percentiles) of the cases (Morgan et al., 2007). The maximum scores in both

experimental and control group were higher than the median score. The range of the experimental group means for the pretest was higher than that of control group. The posttest mean score was slightly higher in the control group compared to the experimental group. The range of the posttest scores decreased compared to pretest scores in experimental group, while in control group the range of the posttest scores increased compared to pretest scores. Figure 4.7 demonstrates the clustered boxplot for the scores of the PREASD and POSTASD for the experimental and control groups.

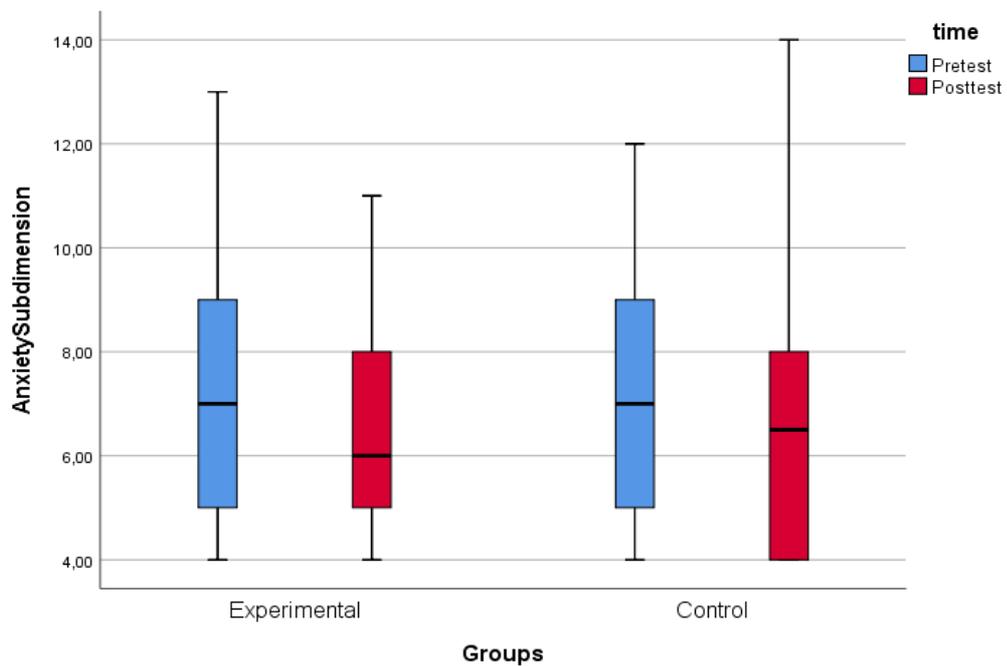


Figure 4.7. Boxplot for the PREASD and POSTASD.

Normality Test for Anxiety Subdimension: As demonstrated in Table 4.12, the Skewness and Kurtosis values of both experimental and control groups were between -1 and +1 in both testing times. However, the results of the Kolmogorov-Smirnov test were non-significant for the pretest scores of experimental and control groups, and posttest scores of the only experimental group. The results of Shapiro-Wilk tests were non-significant only for the pretest scores of experimental group. As Field (2013)

stated that these results could be affected by sample size. Q-Q plots showed the normality of distributions as the plots were around the line, and they were not scattered too much from the line. In addition, the distributions were considered close to normal according to histograms.

The Test of Sphericity for Anxiety Subdimension: Since there are two levels of the repeated measure variable (time), Maucly's test cannot be calculated. However, the assumption of sphericity is not a problem when there is only one pair of levels (Leech, Barrett & Morgan, 2008).

The Test of Homogeneity of Variance-Covariance Matrices for Anxiety Subdimension: Since Box's *M* returned a *p*-value that is more than .001, there are no significant differences between variance-covariance matrices (Tolmie, Muijs, & McAteer, 2011). Hence, the assumption was met for the Anxiety subdimension.

Table 4.13

The Results of ANOVA for the PREASD and POSTASD of Experimental and Control Groups

Source	SS	<i>df</i>	MS	<i>F</i>	<i>p</i>	η^2
Between Subjects						
Group	.07	1	.07	.02	.903	.00
Error	306.12	71	4.31			
Within Subjects						
Time (PREASD and POSTASD)	8.68	1	8.68	3.75	.057	.05
Group*Time	5.97	1	5.97	2.58	.113	.04
Error (Time)	164.16	71	2.31			

Table 4.13 represents the results of the second research problem which indicates the change between the pretest and posttest scores for Anxiety subdimension of experimental and control group students taking time into consideration. Results of Mixed ANOVA indicated that the main effect of time was not statistically significant, $F(1, 71) = 3.75, p = .057$. This effect tells us that if we ignore the group of participants, some types of testing time were not rated significantly differently to others, when at $p = .05$. Similarly, there exist a non-significant main effect of group $F(1, 71) = .02, p > .05$. This effect tells us that if we ignore the testing time, experimental group's Anxiety Subdimension scores did not differ from that of control group. In addition, the results also indicated that there was not a significant interaction between group and time, $F(1, 71) = 2.58, p > .05$. This result demonstrates that the Anxiety Subdimension scores of subjects in two testing times (pretest and posttest) did not differ for the experimental and control groups.

4.3. The Results About the Effect of Instruction on Mathematics Motivation

The purpose of the third research question was to investigate whether there exists a significant difference between the posttest Mathematics Motivation scores of the experimental and control group students. The descriptive statistics of the pretest and posttest of the Mathematics Motivation Scale (MMS) were provided in Table 4.14 below.

Table 4.14

Descriptive Statistics of the MMS Scores on Pretest and Posttest

Group	Time	<i>N</i>	<i>M</i>	<i>SD</i>	Min.	Max.	Range	Skewness	Kurtosis
Experimental	PREMMS	37	130.9	13.8	90.0	153.0	63.0	-1.02	1.04
	POSTMMS	37	133.2	10.1	108.0	149.0	41.0	-.46	-.44
Control	PREMMS	36	132.1	12.3	97.0	155.0	58.0	-.52	.71
	POSTMMS	36	127.7	14.6	92.0	156.0	64.0	-.34	-.21

According to Table 4.14, the minimum scores received by experimental group was 90 for pretest, and 108 for posttest. Additionally, while the minimum score received by the control group was 97 for the pretest, and 92 for the posttest. In order to represent the location and distribution of the Mathematics Motivation Scale scores, the clustered boxplot was used. The box represents the middle 50% (those between 25th and 75th percentiles) of the cases (Morgan et al., 2007). The maximum scores in both experimental and control group were higher than the median score. The range of the experimental group means for the pretest was higher than that of control group. The posttest mean score was also higher in the experimental group compared to control group. The range of the posttest scores decreased compared to pretest scores in experimental group, while in control group the range increased from pretest to posttest. Figure 4.8 demonstrates the clustered boxplot of the PREMMS and POSTMMS for the experimental and control groups.

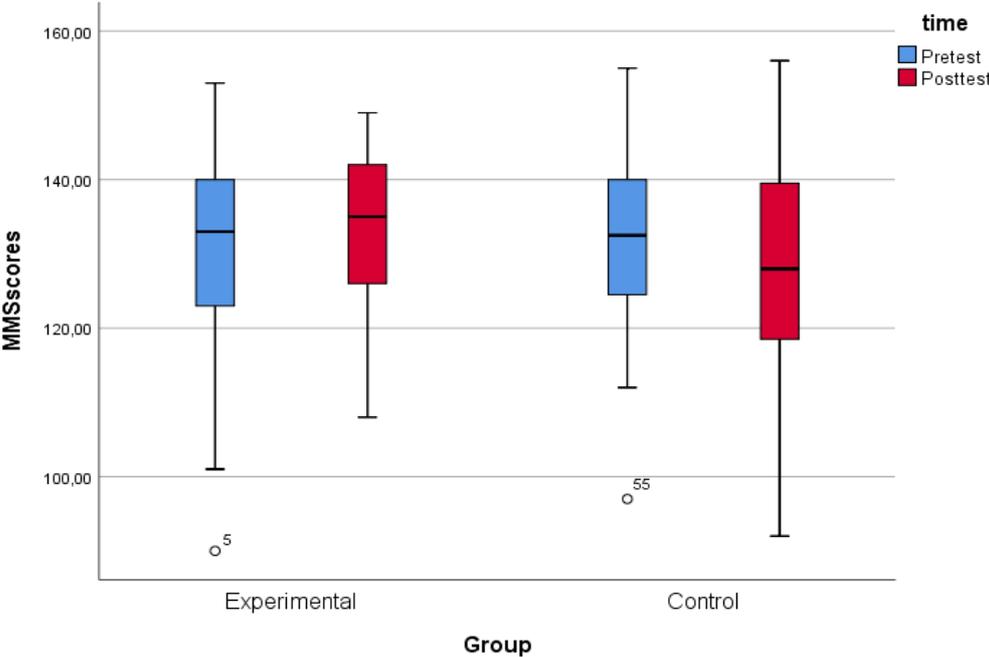


Figure 4.8. Boxplot for the PREMMS and POSTMMS.

A 2x2 Mixed ANOVA with Repeated Measures was conducted to the Mathematics Motivation Scale scores of the experimental and control group students to examine whether there were group and time differences in the MMS scores. Before conducting the mixed ANOVA, the assumptions which consisted of normal distribution of the dependent variables, equality of error variances and equivalence of population covariance matrices were checked for the Mathematics Motivation Scale scores. Since the dependent data comprise the *within subjects* or *repeated measures* factor, the independence of observations assumption was ignored (Leech, et al., 2008).

Normal Distribution of the Dependent Variables: In order to check the normality assumption, Skewness and Kurtosis values, Kolmogorov-Smirnov and Shapiro-Wilk tests, histograms and Q-Q plots were taken into consideration (Field, 2013). Except for the pretest scores of experimental group, the Skewness and Kurtosis values of both experimental and control groups were between -1 and +1 for both pretest and posttest MMS scores (see Table 4.14). However, the values for skewness and kurtosis between -2 and +2 can also be considered as acceptable (George & Mallery, 2020). Similarly, except for the pretest scores of experimental group, the results of the Kolmogorov-Smirnov and Shapiro-Wilk tests were non-significant for experimental and control groups. As Field (2013) stated that this result could be affected by sample size. However, Q-Q plots showed the normality of distributions as the plots were around the line, and they were not scattered too much from the line. In addition, the distributions were seen approximately normal from the histograms.

The Assumption of Sphericity: The sphericity assumption must hold for levels of the within subjects variable at each level of between subjects variables. This assumption was tested using SPSS with Mauchly's test. Since there are two levels of the repeated measure variable (time), Maucly's test cannot be calculated. However, the assumption of sphericity is not a problem when there is only one pair of levels (Leech, Barrett & Morgan, 2008).

Homogeneity of Variance-Covariance Matrices: This assumption was tested using Box's M statistic. It should be accepted as indicating a problem only if it shows a significant departure from homogeneity at $p = .001$ or less (Tolmie, Muijs & McAteer,

2011). Since Box's M returned a p -value that is more than .001, there are no significant differences between variance-covariance matrices. Hence, the assumption is not violated.

Table 4.15 represents the results of the third research problem which indicates the change between the pretest and posttest scores of MMS of experimental and control group students taking time into consideration.

Table 4.15

ANOVA Results for the PREMMS and POSTMMS Scores

Source	SS	df	MS	F	p	η^2
Between Subjects						
Groups	85.57	1	85.57	.61	.44	.01
Error	10048.88	71	141.53			
Within Subjects						
Time (PREMMS and POSTMMS)	43.10	1	43.10	.96	.331	.013
Group*Time	404.66	1	404.66	8.99	.004	.11
Error (Time)	3194.78	71	44.99			

Results of Mixed ANOVA indicated a non-significant main effect of time, $F(1, 71) = .96, p > .05$. Similarly, results of Mixed ANOVA indicated that the main effect for group was statistically non-significant $F(1, 71) = .61, p > .05$. However, the results of Mixed ANOVA indicated that group interacted in some way with the two different testing times of Mathematics Motivation Scale. Thus, there was a significant interaction between the time of the testing and the group of the participants, $F(1, 71) = 8.99, p < .05$. According to Cohen (1988), this effect can be considered as medium

or typical as $\eta^2 = .11$ (Cohen, 1988; Leech et al., 2008: p. 81). The significant interaction effect tells us that scores of participants in two different testing times (pretest and posttest) were different for experimental and control group students. The significant interaction term indicates that the scores taken from POSTMMS compared to PREMMS by the experimental group students are significantly higher than the scores of the control group students. The mean scores of the experimental and control group across pretest and posttest can be seen in the Figure 4.9 below.

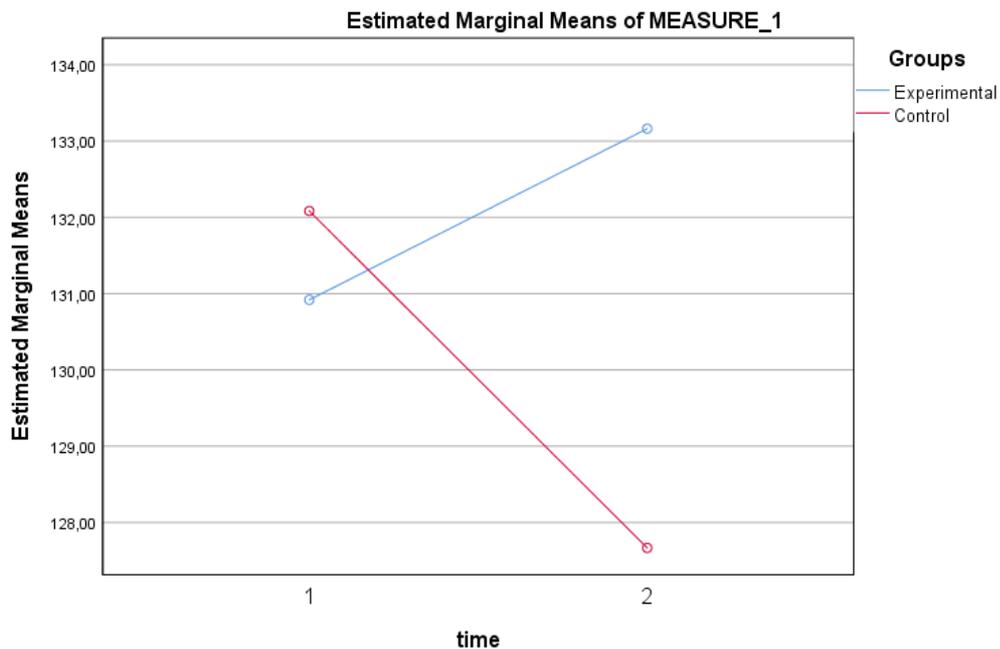


Figure 4.9. Mathematics motivation scores of the groups on pretest and posttest.

According to the Figure 4.9, the experimental and control groups have very near scores on pretest. While the experimental group students increased their scores on Mathematics Motivation Scale, the control group's scores on the same scale decreased substantially on the posttest. Therefore, the direction of the line between the PREMMS and POSTMMS of the two groups are different. It can be concluded that the Mathematics Motivation Scale posttest scores compared to pretest scores are greater for the experimental group than that of the control group.

4.4. The Opinions of Experimental Group Students About the Instruction

The purpose of the fourth research question was to explore the opinions of students about the instruction designed according to Flow Theory principles and enhanced by RME approach. In this part of the study, the results obtained from student interviews, classroom observations and students' diaries about the instruction were presented. The analysis of qualitative data was carried out through thematic analysis as described in the method chapter. The main categories and themes were demonstrated in Figure 4.10 in order to provide an overall framework of the qualitative results.

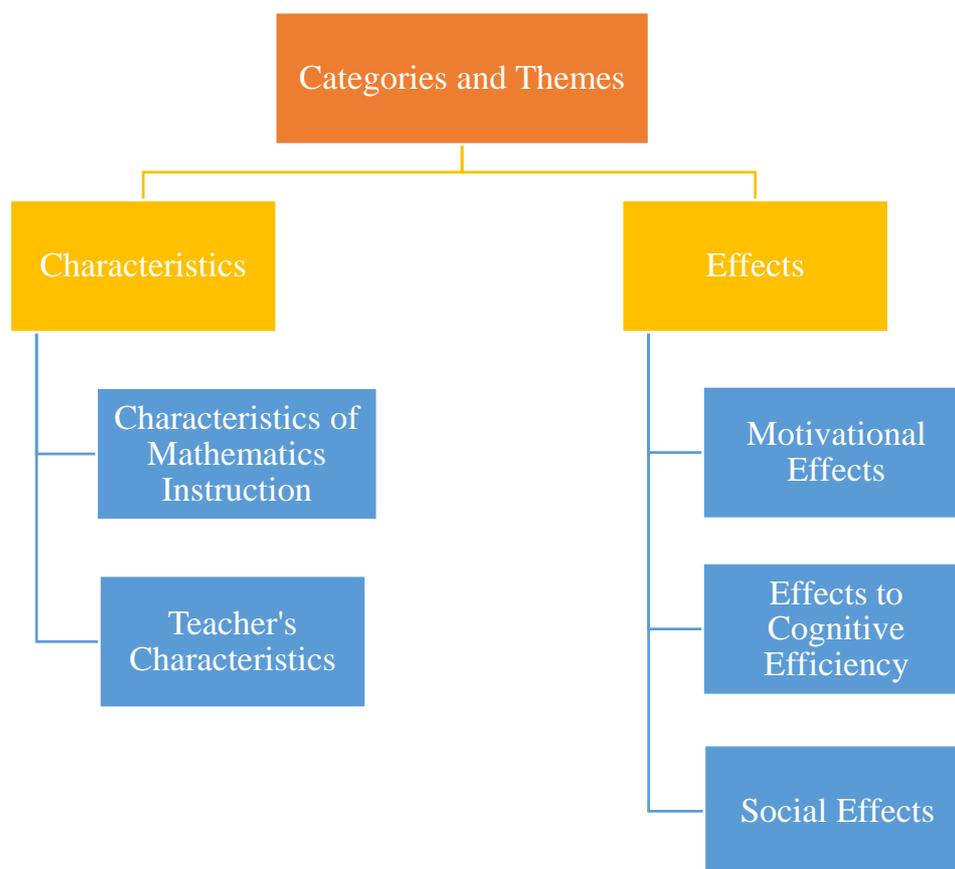


Figure 4.10. The opinions of experimental group students about the instruction.

The results of the thematic analysis yielded two main themes/categories labeled as *Characteristics* and *Effect*. The characteristics category was discussed under two

themes: *Characteristics of Mathematics Instruction* and *Teacher's Characteristics*. The second category, the effects of instruction, yielded three themes which were labeled as *Motivational Effects*, *Effects to Cognitive Efficiency* and *Social Effects*. Moreover, some of these themes yielded some sub-themes as well. All the themes, sub-themes and their corresponding codes will be presented in the following paragraphs below.

4.4.1. Characteristics.

The *characteristics* category emerged from thematic analysis was examined under two themes: *characteristics of mathematics instruction* and *teacher's characteristics*. These themes, their sub-themes and corresponding codes were described in detail below.

4.4.1.1. Characteristics of mathematics instruction.

Table 4.16 demonstrates the characteristics of mathematics instruction in the experimental group and their corresponding codes.

Table 4.16

The Codes Related to the Characteristics of Mathematics Instruction

Theme	Codes	f_{int}	f_{obs}	f_{dia}	f_{total}
Characteristics of mathematics instruction	1. Challenge	10	2	3	15
	2. Clear goals	7	11	-	18
	3. Clear & Immediate feedback	9	10	3	22
	4. Sense of autonomy/control	8	11	1	20
	5. Interest	4	15	-	19

As demonstrated in the Table 4.16, the mathematics instruction based on Flow Theory included the following elements: *Challenge* ($f = 15$), *Clear Goals* ($f = 18$), *Immediate and Clear Feedback* ($f = 22$), *Sense of Control* ($f = 20$), and *Interest* ($f = 19$).

The first observation in the implementation of instruction designed according to Flow Theory was that the *challenge of the activities* was suitable for the students. The subjects frequently stated that the challenge of most of the activities and tasks were medium, although some claimed that a very small number of activities were difficult or easy. Some of the students pointed out their thoughts as follows:

[The challenge level of the activities] was not very high, it was medium, it was the level I could do. There were questions that we could not do, then we were dealing with it. If they were too hard, it would be very annoying. (*S4-High Achiever, Interview*)

The challenge of the activities in math lesson was medium, so it was better. It could also be nice if they were easy, but we can see our learning level more accurately when the challenge is medium. (*S5-Medium Achiever, Interview*)

While talking about the challenge level of mathematics instruction, one of the students made a comparison with previous mathematics lessons and expressed his/her thoughts as follows:

Normally, [in the previous mathematics lessons] the teacher would tell us the definitions, we would learn them by writing down in the notebook. Then, the teacher would tell on the board, the lesson ends after that. On the other hand, since we learned the subjects through activities in these lessons, the level of challenge in these lessons was higher for me. Because when our teacher taught us, we had just solved the questions and passed. In these activities, we are trying to show what we learned. (*S3-High Achiever, Interview*)

As a further response, one student stated the types of activities he or she prefers to do in terms of challenge level as follows:

What motivates me in math class are problems and more difficult, intelligence problems. I like the difficulty more. If there were tasks that were easy, there would be things we had always worked with and learned before. However, I can improve myself more by dealing with difficult tasks. (*S2-Low Achiever, Interview*)

Another characteristic that the instruction implemented in the experimental group was that the activities or tasks had *clear goals*. The subjects stated that the learning

activities in these instructional practices had understandable and clear goals. The students expressed their feelings as follows:

In the lesson, I understood what was asked of us from the explanation of our teacher. At first, she was telling the purpose of the activity. In addition, what we were asked to do was also written on the activity sheets, for example, *design a robot*. Then there were shapes, pictures like robots at the bottom, so I understood what our purpose was. (S7-Low Achiever, Interview)

I was first taking a look when the teacher gave us the activity materials. "What is it about?" I was looking at. I was discussing with my friends. We were looking at what the topic was. After finding it, we were concentrating on it. (S9-Medium Achiever, Interview)

As a further response, S9 included why the goals should be clear as follows:

[When the goals are clear,] the activity became easier, and we can finish it more quickly. In this way, we could easily understand the subject. (S9-Medium Achiever, Interview)

During the observations, there were two different noteworthy situations in appearing the purpose of the activity, which support the students' declarations. First, the teacher explained herself what the students were expected to do for the activity just before the activity started. In the second case, the teacher asked the students to discuss what the purpose of the topic was, and then to ask teacher for clarification if needed. In both cases, it was aimed to make the goals of the learning activities clear for the students. Some of the related observation notes were as follows:

The students understood the goal of the activity and what was expected of them based on the teacher's explanations and the directive of the activity. (O2, Observation)

The students seemed to have understood the goals of the activity easily, thanks to the statements made by the teacher before starting the activity and the instructions in the activity papers. (O4, Observation)

Students who read the instructions of the activity confirmed what the purpose of the activity was by arguing it with their group friends. (O11, Observation)

The other characteristic of the instruction designed based on Flow Theory principles was *immediate and clear feedbacks*. The students in the experimental group stated that when they needed, they could ask their questions to their friends in the group, ask for help from the teacher, and suggest and contribute to their friends' ideas. Some of the expressions used by students about feedback were as follows:

For example, let's say I couldn't do anything, I could ask my friends, 'How did you do this, I couldn't do it?' or let's say, 'My suggestion was this, what's yours?', 'How could you do it?' I was asking them. ... I was getting help when I needed it. My friends were helping me because I was very good with my friends, and I also helped them with everything. (*S2-Low Achiever, Interview*)

Sometimes I did not understand some subjects. Therefore, I asked my friends during the activity. My teammates gave me very good answers when I asked ... I was asking my questions such as *How did you do this?* ... and my friends were immediately helping me. They were telling me directly without any hesitation if they knew the answer. (*S9-Medium Achiever, Interview*)

In addition, the students emphasized the benefits of receiving feedback as follows:

I wouldn't learn if I didn't ask anything. I have to ask. For example, when I wonder something, I think about it for a long time, so I spend my time on it. But when I ask [someone], for example, I can quickly learn and comment accordingly. Hence, getting feedback has a good effect on my learning. (*S3-High Achiever, Interview*)

These feedbacks I received helped me better understand subject matter. Thus, I think receiving feedback is good. As the activities bring us together, we brainstorm better, and everyone has a better knowledge of mathematics. (*S9-Medium Achiever, Interview*)

One of the students stated that thanks to the teacher's helps as feedback, they got rid of their anxiety that they had in the previous mathematics lessons, and wrote in the diary as follows:

In previous math lessons, when the teacher asked me a question about a topic that I was not very good at, I was very worried. In these activities, our teacher helps us more during such moments. So, I am very glad and happy for this. (*D12, Diary*)

During the classroom observations, it was witnessed that the teacher gave feedback to the students, the students gave feedback to their group-mates, and the students were given feedback by other groups' members during the discussion. Besides, the teacher encouraged the students to give feedback to each other. Some observation notes about this issue were as following:

During the activity, the teacher made students understand the subject by giving immediate feedback to the questions asked by them or by asking additional questions. Students with higher academic achievement were helping their peers and answering their questions. (*O7, Observation*)

During the class discussion between the groups, the teacher provided the opportunity for other students to give feedback and make corrections to the

answers given by asking questions to the whole class such as ‘Does anyone want to comment on this answer of your friends?’ (O2, *Observation*)

Giving students *a sense of control or autonomy* has emerged as another characteristic of treatment. One of the remarkable elements in the experimental group was that students made their own decisions in group studies, did not hesitate to take risks and made mistakes, and expressed their thoughts freely. In response to this result, some of the students expressed their feelings as follows:

I always felt free. I was telling my ideas, and they (group mates) agreed with me saying ‘okay, it can be’. While doing the activities, we sometimes took into account my opinions and sometimes those of my group mates. It was changing. (S4-*High Achiever, Interview*)

We could do what we wanted. For example, our teacher does not restrict us, because even if we do wrong at work, she does not get angry, does not restrict, does not say ‘do not make a mistake’. Thus, I was feeling free most of the time. (S10-*Medium Achiever, Interview*)

During classroom observations, findings about the autonomy of learners were reached. Rather than reinforcing the students who answered the questions correctly, the teacher was struggling to encourage and increase the number of students who shared their ideas even when they were not sure about the answer. Some notes from observations included:

The students in all groups did not hesitate to share their solutions regardless of whether they were correct or not. As they saw that making mistakes was also fun in the game and added excitement to the activity, almost all students asked to speak to voice their opinions. (O7, *Observation*)

One of the students stated their feelings in the diary as follows:

The teacher said ‘well done’ to me even though I did not remember the correct answer. (D22, *Diary*)

The last characteristics of the instruction that emerged through interviews and observation results was that it attracted the *interest* of the subjects. In particular, it was determined that the activities which included real life examples, required the use of technology and materials, and provided some physical activity attracted the attention of the students. Additionally, the students stated that they found mathematics interesting because it might affect their success in the future. Some of the statements about this characteristic were reported by the students as follows:

The shopping activity was the most fun for me. ... Because everyone felt like somebody that the employees working in those markets. And everyone thought of themselves as real customers. (S2-Low Achiever, Interview)

I am very interested in robot designs and sailboat designs. I was having a lot of fun in the activities that I designed, that required engineering. (S3-High Achiever, Interview)

Mathematics lesson attracts my interest, because I think I will be very successful in the future thanks to math lessons. Mathematics is a must course. (S7- Low Achiever, Interview)

In addition, some observation notes about the *interest* were as follows:

Based on the story written about a carpenter, the students drew the right pieces of equal length on the given pieces of wood with great interest. (O4, Observation)

Students seemed to show great interest while drawing about quadrilaterals using dynamic geometry software. (O9, Observation)

4.4.1.2. Characteristics of teacher.

According to the thematic analysis results, *Characteristics of Teacher* was determined as another theme. The codes for this theme were labeled as *Using Positive Affect* ($f = 13$) and *Teaching Technique* ($f = 24$). Table 4.17 shows the codes for the characteristics of the teacher.

Table 4.17

The Codes Related to the Characteristics of Teacher

Theme	Codes	f_{int}	f_{obs}	f_{dia}	f_{Total}
Characteristics of the teacher					
	1. Using positive affect	6	3	4	13
	2. Teaching technique	4	9	11	24

According to the results of the thematic analysis, some affective qualities of the teacher were obtained. While conducting the teaching activities in the classroom, the teacher was very kind towards the students, avoiding using a threatening language and style,

creating a comfortable and fun classroom climate. The teachers' being polite, tolerant, and sympathetic towards students, made them feel valued and feel loved by their teacher. Some of the responses of students both in the interviews and in their diaries include:

I felt that I would have a good time with the teacher on the day of the mathematics course, and we would have a good time with the teacher in our class. Because the teacher is always a fun person. (*S2-Low Achiever, Interview*)

Our teacher tells us in a sweet language, helps us with things we do not understand, explains in a fun way with activities... Which is something very good for me. (*S9-Medium Achiever, Interview*)

The activities and learning we did in mathematics class were better. It was more fun. Maybe other teachers would not be like this, they would immediately shout at us. But our math teacher never shouted at us. She always greeted us with a smile. She would answer our questions by saying 'Yes my boy/girl?'. (*S6-High Achiever, Interview*)

Our teacher is very cute, loves us very much. (*D30, Diary*)

The teacher also made an intense effort and persistence to help the students learn the subjects throughout the entire experimental process. This situation was reflected in the expressions of students. During the classroom observations, it was noticed that the teacher tried to answer many questions of students inside and outside the classroom. She was always well prepared for the activities and did not avoid repeatedly teaching the points that the students did not understand. In addition, she often reminded the students not to hesitate to ask questions they did not understand. Students were aware of her effort and seemed to appreciate her for this reason. Some observation notes and expressions of the students obtained from the interviews are as follows:

The teacher dealt with the students one by one and explained the points they did not understand. (*O2, Observation*)

She is a really good teacher. She explains everything well. She always asks when we do not understand. Even if just one student does not understand the subject, she immediately teaches it again. (*S7-Low Achiever, Interview*)

When there were things that we didn't understand, she was answering our questions, so it was good. (*S8-Medium Achiever, Interview*)

As presented in Table 4.17, another code obtained from the thematic analysis results was related to the *teaching technique* of the teacher. Both in the interviews and diaries,

students mostly stated positive opinions about the teacher's teaching technique. Although the students did not express in detail which aspects they liked the teacher's teaching technique, they generally expressed it as the *teacher's teaching style*. They mentioned that the way teacher taught the lesson was good, fluent, efficient and pleasant. Those positive features made some students find the mathematics enjoyable, and they become eager to learn. Some of the students' answers about this issue as follows:

I find math classes enjoyable because our teacher really explains it very well. (S7-Low Achiever, Interview)

The lessons were fun with the good teaching of the teacher in mathematics. I mean, we did some activities in classes. It was such a good thing; the teacher was telling well about the subjects. (S8-Medium Achiever, Interview)

The beautiful and detailed explanation of the teacher made me more eager. (S10-Medium Achiever, Interview)

In addition, students also talked about the same situation in their diaries. They stated that:

Fortunately, I have such a good and beautiful teacher. I love my teacher so much. The teacher's teaching is very good for me. (D20, Diary)

You explain everything very well. (D34, Diary)

Additionally, the teacher frequently encouraged the students to share their opinions regardless of whether they were questionable or not, and gave a chance to reach alternative solutions. She questioned how the students' answers were obtained while conducting in-class activities, rather than just giving feedback as right or wrong. In addition, when students asked to answer or to share their opinions, they were also exposed to questions such as why do you think so? and does anyone have a comment on your friend's answer?, in order to probe for explanation and justification. Some examples from the interviews and observation notes are as follows:

In the activities, we tried to show how we learned more than just finding the right answer. So, I learned better at the activities than the (previous) mathematics teaching. Previously, we only solved the questions and continue. (S3-High Achiever, Interview)

While the students showed their drawings on the smart board, the teacher asked the other students to think about whether they could solve the problem in another

way and in what other ways they could draw the correct pieces of equal length. (O4, Observation)

While the teacher asked the groups to share their answers, she asked them questions like, “Well, is there any other way of solving this? Why do you think your friends chose this way here?” Asking for such alternative solutions contributed to students understanding the process, not just finding the right answer. (O10, Observation)

4.4.2. The effects of instruction.

The second category, the effects of instruction, yielded three themes which were labeled as *Motivational Effects*, *Effects to Cognitive Efficiency*, and *Social Effects*. The themes and sub-themes were shown in Table 4.18

Table 4.18

The Themes and Sub-Themes for the Effects of Instruction

Themes	Sub-Themes
Motivational Effects	<ol style="list-style-type: none"> 1. Intrinsic Motivation 2. Extrinsic Motivation
Effects to Cognitive Efficiency	<ol style="list-style-type: none"> 1. Effects on Learning 2. Intense Concentration 3. Immersion
Social Effects	<ol style="list-style-type: none"> 1. Positive Effects 2. Negative Effects

4.4.2.1. Motivational effects.

One of the themes derived from the qualitative data was *Motivational Effects*. This theme was addressed under two sub-themes: *Intrinsic Motivation* and *Extrinsic Motivation*. Table 4.19 presented these themes and their corresponding codes.

Table 4.19

The Sub-Themes and Corresponding Codes for Motivational Effects

Sub-Themes	Codes	f_{int}	f_{obs}	f_{dia}	f_{Total}
Intrinsic motivation					
	1. Autotelicity	10	9	41	60
	2. Effort	5	3	2	10
Extrinsic Motivation		3	3	1	7

4.4.2.1.1. Intrinsic motivation.

Codes derived from thematic analysis regarding the positive feelings or affects, and elements resulting from such emotional states were brought together under the sub-theme of *Intrinsic Motivation*. As seen in Table 4.19, the instruction in the experimental group enabled that students participate in the activities for the sake of activity - *autotelicity* ($f = 60$), make an *effort* to learn mathematics ($f = 10$).

First of all, the students wanted to participate in the activities because they found the activities autotelic, felt good, had fun and enjoyed them. The classroom observations, students' diaries and responses in the interviews provided strong evidence in this regard. For example, some of the observation notes include:

When students heard that they were going to start activities, they jumped on the floor to show their happiness, they raised their hands in the form of Hoorey! (Oley!) and hugged the friend next to them. At the end of the lesson, the students stated that they had a lot of fun and that they wanted to do such activities in other courses as well, saying that I wish the activity never ended. (*O1, Observation*)

It was observed that the students participated in activities involving physical activity with more fun, such as designing a robot or sailboat model, and pretending to be a shopper. For example, the observation notes include:

The students were looking forward to the transition to the activity as soon as possible. This showed that they were motivated to participate in the activity. In addition, the students had a lot of fun especially when cutting the polygons while sticking them for designing a robot and tried to make the best design. (*O9, Observation*)

In addition, some students stated the following sentences in the interviews showing the autotelic feature of the activities:

I have never said that I wish I was doing something else, because I was having so much fun while doing the activities. At the beginning of the semester, before the activities started, mathematics lesson did not attract my attention, thus I was a little bored with math. However, I started not getting bored anymore when we had the activities, and math attracted my attention. Hence, I did not want to do anything else, I just wanted to learn more math and I wanted to do more activities. Since I had fun while doing the activity, I didn't want the bell to ring. Because, when this activity was over, we were not going to do it again until next week. I didn't want it to end soon, I wanted it to end later. (*S10-Medium Achiever, Interview*)

These math classes and the activities were very enjoyable. I had so much fun doing them because it was like a game. They are better than the previous math lessons. I always want to continue the activity, even when the break bell rang, because they were very enjoyable. (*S3-High Achiever, Interview*)

Math lessons were very, very enjoyable. I was dying to take a math class. (*S4-High Achiever, Interview*)

Although I can't do the math too much, I'm having fun. I love numbers and math terms... I felt very good in math classes since I was having fun. I was very fond of the activities we did in the lesson. I was also telling my friends that the activity day would come, they wanted it too. (*S1-Low Achiever, Interview*)

Moreover, some students stated that they did not experience negative emotions such as boredom and anxiety during the instruction designed by Flow Theory. These feelings seemed to encourage them to do more activities and attend classes. Their responses include:

I must first say that I was never bored. There was never a situation where I had anxiety or stress. So the math lesson was always good, all the activities we did were very good. So there was no memory of sadness in my mind. (*S2-Low Achiever, Interview*)

I've never felt bored. I had no anxiety and stress. It was always very enjoyable. Time was good in math classes, it was always pleasant for me. I wanted to continue the activity even when the bell rang. Because it was both enjoyable and it enabled us to learn more ... I would like to have similar activities in all math classes because we can both have more fun and learn better. (*S5-Medium Achiever, Interview*)

I started to dislike mathematics, at the beginning of the fifth grade. But then activities came (in the second semester) and I had a lot of fun in mathematics. So the activities tied me more to mathematics. (*S8-Medium Achiever, Interview*)

Finally, in the diaries, students mostly said that their mathematics lessons were fun, fluent, and pleasant; they enjoyed the lesson and they wanted to do mathematics more often. One of the subjects stated in the diary as follows:

I was very excited because it was a math class. Because it was a lot of fun that day, I learned new topics. And I was very happy. I wish there was always math class, then I would be very happy.” (D34, *Diary*)

The second code obtained from the thematic analysis was related to the *efforts* of the students for learning mathematics lesson. The students stated the following sentences about the efforts for mathematics, thanks to the activities:

My effort for mathematics lesson increased thanks to these activities. I had a lot of math work at home because I had fun. (S1-*Low Achiever, Interview*)

My effort for mathematics lessons increased. I became more diligent and hardworking thanks to the activities we did in the lesson. Besides, I learned more and had fun in mathematics lessons. (S7-*Low Achiever, Interview*)

Thanks to the activities, we learned not to give up when faced with difficulties, to be motivated and to strive harder to succeed. Thanks to the help of my teacher and my friends, our math motivation was ensured and we built our self-confidence in the group. We improved our ability to express ourselves better, we were able to form our own sentences better in the group. (S6-*High Achiever, Interview*)

4.4.2.1.2. *Extrinsic motivation.*

Although not as much as intrinsic motivation elements, thematic analysis results also revealed some findings about *Extrinsic Motivation* ($f = 7$). These findings are usually in the form of *achieving higher scores* or *gaining one's appreciation*. In other words, when the students were asked what the most motivating elements were in the mathematics lesson, some students stated that it was to get the teacher's favorite, while some others mentioned that it was to get higher grades in exams. For example, some students stated their view about this issue as follows:

What motivated me was getting more grade. It would also motivate me to get my teacher's favorite. (S3-*High Achiever, Interview*)

The things that motivated me were the exams. (S4-*High Achiever, Interview*)

During the instruction, it was observed that the students paid attention to how the groups that made better designs or solutions were reinforced by other group members

or by the teacher. For example, writing the names of the groups on the board that did the best design or congratulating them were seemed to motivate other group members. One example from observation notes included as follows:

All the designs created by the groups were voted by other group members in terms of their compliance with the criteria in the activity, and the names of the groups that made the best designs were written on the class board. (O5, Observation)

4.4.2.2. Effects to cognitive efficiency.

The second theme emerged as a result of the thematic analysis was related to *Cognitive Efficiency*. According to the thematic analysis results, the instruction implemented in the experimental group contributed to subjects' cognitive efficiency. The thematic analysis results indicated that the instruction they received affected students' *Learning* ($f = 46$), help their *Intense Concentration* ($f = 12$) on subjects, and provided *Immersion* ($f = 25$) during the activities. Table 4.20 presents the contributions of instruction to learning of subjects and their corresponding codes.

Table 4.20

The Codes Related to the Effects to Cognitive Efficiency

Theme	Codes	f_{int}	f_{obs}	f_{dia}	f_{Total}
Effects on Learning					
	1. Learn While Having Fun	6	-	3	9
	2. Effective Learning	18	2	17	37
Intense Concentration					
	1. Focus on the task	5	7	-	12
Immersion					
	1. Losing self-consciousness	5	4	-	9
	2. Time passing quickly	8	2	6	16

The first theme under the category of effects on cognitive efficiency was found to be the *Effects on Learning*. According to the data obtained under this theme, the students

expressed their views on learning in two different ways: *Learning While Having Fun* ($f = 9$) and *Effective Learning* ($f = 37$). The students stated that they had fun while learning mathematics or that they learned while having fun. Some of the students commented that:

I saw how fun the math world was with the activities. So, I understood that math can be done with fun. I always wanted to do activities in math classes, it would be really nice if it were. For example, those who are bad at math are biased towards mathematics. Therefore, their prejudices against mathematics would disappear, and they would see that math was a fun world. (*S9-Medium Achiever, Interview*)

I felt both having fun and learning with my friends while doing those activities. (*S2-Low Achiever, Interview*)

The students also stated that they could *learn effectively* through the instruction designed according to Flow Theory. Some of the students stated that the instructional activities made learning easier, while others stated that their learning could be long-lasting. In addition, some students emphasized that they had difficulty to understand mathematics topics before the treatment, but they could learn them better thanks to these activities. According to some students, the learning was ensured thanks to the activities carried out during the lesson, while some of other students stated that doing group work with friends made sense for their learning. They expressed their thoughts about learning both in the interviews and in their diaries as follows:

Since it was more fun when doing activities, I was learning math well. ... Thanks to the activities, you learn math more easily, so that we do not have to work harder because we learn everything in the lesson. In this way, I do not work too much at home, because when we do an activity, I have already learned enough. (*S10-Medium Achiever, Interview*)

The activities in mathematics class affected my desire to learn mathematics. Because while we were doing them, we had fun and understood on one hand, on the other hand, what we learned remained in our minds. (*S1-Low Achiever, Interview*)

This week I learned very well about angles in Mathematics. (*D6, Diary*)

Additionally, during the activities, students might share incorrect information which include errors and misconceptions. However, it was observed that they shared their knowledge in order to help each other understand the subject by correcting the errors

and misconceptions. The following situation that stands out during the observations was an example of this issue:

It was seen that the students used their prior knowledge while defining the rectangles. Some of this prior knowledge contained errors or misconceptions. For example, they used the concept of 'trapezoid' in Turkish meaning 'a shape that inclined to one side' or 'irregular' in daily use. It was noticed by other students in the group that the definition was wrong and they helped their group-mates to understand the difference between the two definitions. (O6, *Observation*)

Another contribution of the instruction designed according to Flow Theory related to effective learning was about transferring. The students in the experimental group reported that they could transfer the knowledge and skills they learned from the lesson to other lessons or to other subjects of the mathematics lesson. For example, some of the students stated that:

The activities in mathematics class affected my desire to learn mathematics. Because we have been more successful in other courses with what we learned in mathematics. (S1-*Low Achiever, Interview*)

I was bad at the measurement of area before the activities. I got better and better thanks to the math activities and I was able to demonstrate this in exams, and other tests. (S6-*High Achiever, Interview*)

Finally, experimental group students noted that with this instruction, they started to learn better since they started to study mathematics more and to solve problems by themselves. One student expressed their thought as follows:

Thanks to these activities, the time I spent studying mathematics increased. For example, while I was working 1-2 hours before, I started studying 3 hours a day or so. Also, I started to spend more time studying math on the weekends. (S5-*Medium Achiever, Interview*)

Another result of the thematic analysis was that students were able to have *intense concentration* during the math lesson. Some of the students pointed to the following feelings:

I did not hear what my friends in the class were saying, nor the noise they were making. I was very focused on the activities done in the lesson. (S5-*Medium Achiever, Interview*)

In addition, the following notes were obtained during the classroom observations about students' concentration:

When the groups started to make their designs, the gabble in the classroom turned into silence and the students concentrated on their designs. (O1, Observation).

As soon as the teacher handed out the students the activity papers, it was observed that the students focused on the activity with great curiosity, so they did not hear some of the explanations made by the teacher. (O11, Observation)

Another cognitive effect of Flow Theory-based instruction was that it caused students to experience a sense of *immersion*. This concept emerged as a feeling of *losing self-consciousness* and a feeling of *time passing quickly*. The findings reflecting this code, which is one of the basic indicators and concepts of Flow Theory, are as follows:

I was losing myself during the activity. I forgot the break, I forgot my friends, I was immersed in the paper in my hand, I was just thinking. Sometimes I even forgot that I was in class because I was very focused while doing something. The reason for this is both desires, ambition, sense of success, and entertainment, team unity, and things like that. (S7-Low Achiever, Interview)

Since I have so much attention to something, I don't mind anything else other than the activity. For example, my friends yell a lot in the groups, but I focus on my task and never care about anything other than it. (S2-Low Achiever, Interview)

For example, we were doing an activity about measurement of time. I was just thinking about the activity while solving them. I had already finished it all, but I kept thinking about the task until I realized that we were going to start another lesson. I was ruminating a lot. I didn't want to go to another class. The reason for these feelings may be because I like math lesson a lot, it is fun, and I get help from my teacher and my friends. (S4-High Achiever, Interview)

There were moments when I did not realize how time flew. Time was flowing like water for me. That was so fun. We couldn't understand how to grasp time. At first, hard things flowed like water. Easy things were finished quickly, and we were waiting for others. But we were losing ourselves more in difficult activities. We didn't know how time went by. Even though the time flew by, we were trying again. We were more motivated and more working hard to do the activity to get it done right away. (S6-High Achiever, Interview)

When the activity materials were given, we would always gather with my friends, take the opinions of each other and immediately dive into the subject. That forty minutes passed for me like three minutes. (S2-Low Achiever, Interview)

Generally, time passes quickly in mathematics lessons. Because it's fun. I like team unity. Time passed very quickly, we never really understood. The lessons seemed to take 10 minutes or so." (S7-Low Achiever, Interview)

Time passed very quickly in math class, because when you do activity, you have fun and you do not understand how time passes. (S10-Medium Achiever, Interview)

In the diaries they wrote, the students expressed their thoughts about the completion of the lessons and the passing of time quickly. They stated their feelings as follows:

The course was fluent. I don't understand how the time went. (D28, Diary)

The lesson was a lot of fun, it ended very quickly. (D29, Diary)

The course was very good today. Our lesson was very fast, I didn't understand what happened. (D14, Diary)

4.4.2.3. Social effects.

According to thematic analysis results, the instruction designed according to Flow Theory principles had effects on social factors. However, this theme was handled under two sub-themes because both *positive* and *negative effects* were observed regarding the social effects. Table 4.21 presented these sub-themes and their corresponding codes.

Table 4.21

The Sub-Themes and Corresponding Codes for the Social Effects

Themes	Codes	f_{int}	f_{obs}	f_{dia}	f_{Total}
Positive Social Effects					
	1. Cooperation	7	11	-	18
	2. Democratic Attitude	2	2	-	4
Negative Social Effects					
	1. Conflict	2	3	-	5
	2. Competition	2	1	-	3
	3. Physical Conditions	-	1	4	5

4.4.2.3.1. Positive social effects.

As seen in Table 4.21 the positive effects of the instruction regarding the social dimension were labeled as *Cooperation* ($f = 18$) and *Democratic Attitude* ($f = 4$).

The first social effect in a positive sense was that the students learned to cooperate, help each other and contribute to each other's learning in the instructional activities based on Flow Theory. While students learn to work in cooperation, they communicated with their friends face to face or on social media, and shared their thoughts about activities, asked their questions to the classmates. By this way, this instruction method helped students strengthen their friendship as well as learn to study cooperatively. Some examples of students' statements and observation notes about cooperation can be given as follows:

It was observed that students help each other's drawings within the group. (O4, *Observation*)

The individuals in the group were doing their best for each other to learn, as they had to make a logical explanation of the answers given. (O8, *Observation*)

I feel good in math classes, because of the support of my friends, as we go together with teamwork. They comfort me, and I comfort them. Everything is not on me, not on them. We progress by helping. When something bad happens, for example, when we can't do anything, another friend helps us. I love mathematics lessons because there is cooperation. (S7-Low Achiever, *Interview*)

In math class, we become a real team with my teammates, which making me feel intimacy with my friends. Our friendship was getting better, never breaking. Friendship relations were getting better. (S9-Medium Achiever, *Interview*)

When we found different results in the questions, we were arguing among us. Hence, the math lessons were very good, because we would do discussions. In addition, we did not make individual, we did together with our teammates, and we were collaborators. (S8-Medium Achiever, *Interview*)

When the mathematics lesson finished, we were talking to other groups about how we learned or what happened today. When we went home, we were solving questions together. We also had a group on social media where we shared our thoughts about what we would learn in the activity. When the activities were over, we started not to talk too much about math. (S8-Medium Achiever, *Interview*)

Later on, the other positive effect of the instruction on social dimension of the students was about *Democratic Attitude*. The thematic analysis revealed that the activities in mathematics contributed to the development of students' perceptions about the concepts like democracy, equality etc. While explaining how they decided on the designs as a group during the activities, another student used the following expressions that could be an example of democratic attitude:

During the activities, everyone was drawing their own ideas on paper. Later, we also agreed by voting among us. We were all looking, everyone chose one of the designs. As a result, we were deciding together. (*S4-High Achiever, Interview*)

While one of the students was explaining how they did the division of labor during group work, he used the following expressions about the equality:

Actually, I'm not different from them, I'm similar to them. So they were making me the head of the group as well, and I was very happy at those activities. (*S6-High Achiever, Interview*)

4.4.2.3.2. *Negative social effects.*

In contrast to positive effects, the thematic analysis revealed some negative social effects of instruction. As seen in Table, 4.21, these effects were labeled as *Conflict* ($f = 5$) and *Competition* ($f = 3$) and *Physical Conditions* ($f = 5$).

The first negative social effect was about the *conflict* of opinion especially among students who were teammates. During the activities, it was reported that there were differences of opinion and even quarrels between the subjects for various reasons. For example, not being able to distribute tasks equally, not considering each other's opinions, not contributing enough to group work are some of them. While one of the students were explaining why they would sometimes wish to do something else other than that activity, he reflected the following sentences:

Sometimes there were small disagreements with my friends, when we were trying to decide how we should do the tasks. At that time, I would think that I wish I was doing something else. (*S8-Medium Achiever, Interview*)

Later on, another student expressed their complaint about their ideas being ignored, although he liked the activity:

Although the activities were very nice, I had a problem in an activity, because of my friends. They didn't care about some of my ideas. (*S2-Low Achiever, Interview*)

According to the results of the thematic analysis, it was revealed that some of the students had difficulty expressing themselves as a result of this conflict that occurred in some groups. They thought that they would be mocked by their friends because of their wrong ideas. For example, an student stated their feelings as follows:

I felt a bit of stress when I couldn't do my task, or I didn't contribute to my group. I was afraid that my friends would think badly about me. (*S9-Medium Achiever, Interview*)

Another result of the thematic analysis was that students had extreme sense of *competition* during the activities. It was observed that sheer amount of competitive attitude caused problems such as the students experiencing excessive excitement and ambition at the time of activity, having occasional quarrels with other group members and decreased sharing. Some students, on the other hand, expressed their discomfort from the group members who were excited and loud, losing control due to the effect of competition. For example, one of the students stated his feelings as follows:

Sometimes when my friends yelled, I felt bad. Because when they were overly greed like 'we'll do better, we'll do faster', I couldn't learn anything. I don't know why they were doing this, but I was getting bored at that moment. In addition, their voices were getting louder, so I was bored, because we were not doing that. (*S1-Low Achiever, Interview*)

Finally, the *Physical Conditions* of the classroom also had a negative impact on the social dimension, because the classroom was small, while the class was crowded. For this reason, during the activities, there were problems such as students not being able to hear each other due to loud noises and not being able to see the board due to the insufficient seating arrangement. Some of the students stated their thoughts in the diaries as follows:

This lesson I could not see the board. Because the next row of friends is tall and their rows are higher than ours. (*D32, Diary*)

I am a little confused because there is a lot of noise in our classroom. I would like a quieter classroom environment. (*D20, Diary*)

4.5. Summary of the Quantitative and Qualitative Results

In this section, a summary of the quantitative and qualitative results will be presented, and implications for how qualitative data explain quantitative data will be given. In the first research problem, it was examined whether there was a difference between the mathematics achievement and mathematics retention scores of the experimental and control groups. Accordingly, the results indicated that the retention test scores of experimental group were significantly higher than that of control group. In other words, instruction in experimental group had significantly more effect on students'

mathematics retention test scores than the instruction in control group. According to the results obtained from the analysis of qualitative data, the instruction applied in the experimental group had effects on the cognitive efficiency of the students, which supports this result. In particular, the students stated that they learned mathematics better thanks to the activities, their learning was long-lasting, their effort to learn mathematics increased, the subjects they learned in the lesson made it easier for them to learn other lessons and subjects as well.

In the second research problem, it was examined whether there was a difference between posttest Flow, Boredom and Anxiety Subdimension scores of the experimental and control groups. First, the results indicated that the experimental group had significantly higher FSD scores than control group on posttest. Accordingly, students who learned in experimental group experienced more flow state than control group. In addition, instruction carried out in the experimental group had an effect on increasing the flow experiences of the students, while the teaching conducted in the control group did not have any significant effect on the flow experiences of students. According to the findings obtained from the qualitative data, it is seen that the themes of both motivational effects and effects on cognitive efficiency support this finding. Accordingly, in the qualitative data, findings reflecting the flow state such as the students' intense concentration on learning activities during the lesson, the loss of self-consciousness that occurs in the form of forgetting their needs or problems when conducting activities, and the feeling of not being able to understand how time passes were found. In addition, findings were obtained such that the students had fun while learning in the experimental group and that participating in the activities gave them pleasure, which represent the flow experience.

Secondly, the instruction applied in the experimental group provided a significant decrease in the Boredom Subdimension posttest scores of the students, but instruction conducted in the control group did not have any significant effect on the boredom state of subjects. However, the posttest BSD scores of experimental and control groups did not significantly differ after the experimental process. According to the findings obtained from the qualitative data, it was determined in the interviews, observation notes and students' diaries that the students who learned in the experimental group

participated in these lessons with more pleasure, did not get bored in the lesson, on the contrary, they had fun while learning.

Third, the results indicated that the Anxiety subdimension posttest scores of the experimental and control groups did not differ significantly. Additionally, the pretest and posttest scores of each group did not differ significantly. These results seem to indicate that learning through instruction applied in experimental group did not have any effect on reducing students' anxiety. However, some findings obtained from the qualitative data reveal that the students who learned in the experimental group did not experience negative emotions such as anxiety and stress, on the contrary, they enjoyed participating the courses. This supports the finding that students have low anxiety levels both in the pretest and posttest.

In the third research problem, it was examined whether there was a difference between posttest Mathematics Motivation scores of the experimental and control groups. The results indicated that the posttest Mathematics Motivation scores compared to pretest scores of experimental group significantly higher than that of control group. In other words, learning through the instruction applied in experimental group had significantly more effect on increasing students' mathematics motivation than the instruction applied in control group. Findings from qualitative data indicate evidence supporting this result. Accordingly, it was determined that the students learning in the experimental group had both intrinsic motivation and extrinsic motivation experiences. It was found out that the students participated in the mathematics lesson with great enthusiasm, they enjoyed participating in the lesson, they participated in the activities in the lesson for the sake of the activity (autotelicity), and thanks to these activities their effort to learn mathematics increased. Additionally, while intrinsic motivation was the most frequently mentioned sub-theme, students also mentioned that instruction had an effect on their extrinsic motivation. These factors related to extrinsic motivation appear more as the expectation of gaining someone's praise and high grades.

Findings related to fourth research question which asks the opinions of the students about the instruction conducted in the experimental group indicated that the students

in the experimental group generally reported positive opinions, effects and contributions about the instruction. According to the results of the thematic analysis, the findings were discussed under two main categories as *characteristics* and *effects*. While the themes examined under the first category included the characteristics of mathematics instruction and of the teacher, the second category included three themes, namely, the motivational, cognitive efficiency and social effects of instruction. According to the thematic analysis results, the mathematics instruction conducted in the experimental group had some level of challenge, included clear goals, immediate feedback for the subjects, provide a sense of learner autonomy and attracted their interest. The teacher had a positive affective attitude towards students, and her teaching style was found efficient by the students. Additionally, the instruction in the experimental group helped students learn while having fun, feel intense concentration and immersion. Finally, the students mentioned that the instruction they received had mostly positive social contributions such as cooperative learning and democratic attitude, but that sometimes negativities arising from conflict and competition could occur within the group studies.

CHAPTER V

DISCUSSION

In this chapter, the findings obtained from the quantitative and qualitative data were discussed along with the relevant literature. Additionally, recommendations were given in terms of future research and applications in the following sections of the chapter.

5.1. Discussion of the Results

In this section, discussions about the findings obtained from fifth-grade students' achievement, retention, flow state and motivation on Mathematics Test, Flow State Scale in Mathematics and Mathematics Motivation Scale, respectively.

5.1.1. The effect of instruction designed based on Flow Theory and RME approach on mathematics achievement and retention scores.

According to the results presented in the previous chapter, mathematics retention test scores of the experimental group are greater than that of control group, while experimental and control groups' immediate mathematics scores did not differ significantly. In addition, for the experimental group, the difference between pretest and posttest scores, between posttest and retention test scores, and between pretest and posttest scores were found statistically significant. On the other hand, for the control group, the difference between pretest and posttest, between pretest and retention test scores were found statistically significant, while between posttest and retention test scores were found statistically non-significant. This seems to imply that the instruction applied in the experimental group had significant effect on both posttest and retention

test scores, while the instruction applied in the control group had significant effect only on the posttest scores of students.

It is possible to come across studies in the literature supporting the result of the current study that the mathematics posttest scores of experimental and control groups did not differ (Admiraal et al., 2011; Annetta, Minogue, Holmas, & Cheng, 2009; Kirchhoff, 2013). For example, in the quasi-experimental study conducted by Annetta et al. (2009), it was aimed to evaluate whether the game supported instruction created by the teacher has an effect on the cognitive characteristics of the students within the framework of Flow Theory. In the study, no significant difference was observed between the experimental and control groups in terms of learning measured by genetics unit test.

Supporting the result of the current study that Flow Theory-based instruction significantly increased the mathematics posttest scores compared to pretest scores of experimental group, a literature review conducted by Dos Santos et al. (2018) revealed that almost half of the experimental studies indicated that the use of Flow Theory increases learning, but only one of the studies showed that the learning of students who experienced flow decreased. At the same time, this finding is also consistent with the results of a dissertation study conducted by Tunalı (2010) which compared the students' achievements in mathematics teaching using RME principles that are parallel to Flow Theory, and in teaching with constructivist approach. Accordingly, it was concluded that mathematical knowledge was achieved in both experimental and control groups. However, Admiraal et al. (2011) determined that flow has no effect on learning outcome of students, which contradicts the result of the current study. Additionally, the study conducted by Kirchhoff (2013) indicated that the achievement in reading was not related to the flow-type experiences.

One of the reasons why there is no difference between the mathematics posttest scores of the experimental and control groups might be that the students in the experimental group were not accustomed to the intervention, and that the experimental procedure was applied in a limited time. As advocated by Korkmaz (2017) and Aydın Ünal (2008), the continuation of the experimental process in longer periods may positively

affect student behaviors towards the course both cognitively and affectively by increasing the familiarity of students to the instruction type.

The results obtained from some studies in the literature contradict the result that there is no significant difference between the mathematics posttest scores of the experimental and control groups obtained from the current study (Aremu & Adebagbo, 2016; Chang, et al., 2012; Hamari et al., 2016; Heine, 1997; Korkmaz, 2017; Sedighian, 1998; Yetim Karaca & Özkaya, 2017, Zakaria & Syamaun, 2017; Zheng, 2012). For instance, Aremu & Adebagbo (2016) investigated the effect of game-flow strategy on students' mathematics achievement. The results of this study showed that the mathematics achievement of the group exposed to game-based instruction which included flow elements was significantly higher than that of other group exposed to the traditional method of teaching. Similarly, in the study conducted by Chang et al. (2012), mathematical problem-solving skills of fifth grade students who were exposed to game scenarios supported by flow model were higher than the students taught with traditional paper-based method. The results of dissertation study conducted by Korkmaz (2017) revealed that the experimental group students who learned mathematics through RME-based instruction had significantly higher academic achievement scores than that of control group.

In the current study, a significant difference was found between the mathematics retention test scores of the experimental group and the control group in favor of the experimental group. That is to say, instruction based on Flow Theory principles and enhanced with RME was more effective on mathematics in long-term. This can be considered as a positive and important result, since the main purpose of teaching is to provide permanent learning (Song, 1992). When the posttest scores of the experimental group are compared with the retention test scores, it is noteworthy that the experimental group significantly increased its scores even after the experimental procedure. However, when the posttest scores of the control group students are compared with the retention test scores it is seen that the scores of this group decreased. The factors for this result might be that, as revealed in the qualitative results, the instruction applied in the experimental group might have increased the effort of the students. According to Dinapoli (2018), students show deliberate practice, their effort

and perseverance increase in activities which are challenging to them, have clearly-defined goals, provide students the control of their actions and scaffolding. Therefore, experimental group students may have spent more time to learn mathematics after school. Additionally, instruction they received might have enhanced their effort to learn mathematics and made them realize that mathematics is important and useful in daily life. Realistic tasks may have increased students' interest in mathematics, made them more dabble in studying mathematics, because students in experimental group learned through play-like activities which were appealing to them. They have the opportunity to learn mathematics as if they were playing a game, by being physically active, explore new things, increase their boundaries, interact with peers. Thus, students may have participated the learning activities for the sake of learning mathematics and might have continued to study and learn mathematics with their own efforts, since studying mathematics kept their interest even after the experimental process ended.

One of the reasons why the experimental group students achieved significantly higher scores in the mathematics retention test might be that the students in this group learned with RME approach. In the RME approach, students have the opportunity to learn concepts in a way similar to the invention of mathematics by guided reinvention principle. In this method, students acquire formal knowledge based on informal strategies. In addition, students can create their own learning models based on real-life examples and can provide meaningful learning of concepts in line with the horizontal and vertical mathematization process. As a result, learning based on experiences and needs in daily life ensures more long-lasting knowledge (Bintaş et al., 2003; Freudenthal, 2002; De Lange, 1987; Gravemeijer, 1994). The RME approach may have enabled students to overcome their difficulties about the mathematics course and to learn mathematical concepts as a part of daily life, thus ensuring that the learning is permanent (Yetim Karaca & Özkaya, 2017). In the literature, there are several studies supporting the finding that using the RME approach in mathematics teaching positively affects students' retained scores in mathematics (Bintaş, et al., 2003; Can, 2012; Demirdöğen, 2007; Ersoy, 2013; Verschaffel & De Corte, 1997). For example, in the study conducted by Verschaffel and De Corte (1997), the mathematics retention test scores of fifth-grade students studying with RME reveal that this method has a

longer effect even after the experiment ends. Similarly, Can (2012) determined that 3rd grade students who learned with RME-supported mathematics teaching obtained significantly higher retention test scores than the control group in which the activities in the textbook prepared with the constructivist approach were applied.

The use of RME in the experimental group may have enabled the students to obtain more retained scores in mathematics, as RME attracted the interest of the students. The use of RME approach in flow-based instruction might be effective on this result due to didactical phenomenology principle. This principle requires that the instructors design appropriate problem situations and sample procedures in which students reach generalizations and vertical mathematization (Altun, 2008), as mathematics emerged from similar ways in historical processes (Bintaş, et al., 2003). Thus, students might find the opportunity to learn the information permanently, not by memorizing the concepts, but by researching, discussing and trying the solutions to the problem situations that meet their needs. Learning mathematical concepts based on the needs and problems encountered in daily life might help to attract students' interest. The study of Schiefele & Csikszentmihalyi (1994) demonstrated that interest contributed significantly to the prediction of achievement in subjects such as mathematics, biology and history. In another study conducted by the same researchers, the results showed that the interest and achievement mutually affect each other (Schiefele & Csikszentmihalyi, 1995). According to RME approach, the more the subjects are related to the students' experiences and are exemplified from their daily lives, the more interest of learners and permanent learning of the subjects will occur (Demirdöğen, 2007). Finally, in the study conducted by Bintaş et al. (2003), it was determined that seventh grade students who learned symmetry as suggested by the RME approach retained the knowledge for a long time, even though they did not do any repetition after the treatment process.

Another reason for the result that experimental group had significantly higher mathematics retention test scores than the control group might be the immediate feedbacks provided to students when they needed, which is supported by different studies in the literature (Jang & Marshall, 2018; Phye & Bender, 1989). According to the results of the study conducted by Jang & Marshall (2018), feedback provided long-

term retention of the students by strengthening the memory of the correct answers and correcting their mistakes/errors in their prior knowledge and reinforcing the correctly learned information. Similarly, according to the results obtained from the study conducted by Phye & Bender (1989), it was revealed that the immediate feedback had a significant effect on the retention scores of the test applied to measure the university-level students' learning of several difficult vocabulary items. In the current study, the students were given immediate feedback from their teacher and group mates, as the feedback has a function that can initiate mental processes such as evaluating newly learned information, comparing this information with existing ones, and revealing and/or rearranging beliefs (Brandl, 1995).

Moreover, the reason for obtaining such a result might be that the students in the experimental group were taught through cooperative learning, supported to study with their peers in order to complete the given tasks. There are studies in the literature which support this finding. For instance, Topping (1996) stated that learning with peers and studying cooperatively enabled individuals to discuss their opinions, to apply what they have learned more effectively and easily, to have more meta-cognitive awareness and to improve their long-term retention. In addition, providing opportunities for interaction, communication, and relationship with more than one participant in a cooperative learning environment will make it easier for students to have different experiences, to learn by discovery and to acquire new information, and will have a positive effect on the retention of what has been learned (Lynch, Holden, Foley, Harrington & Hussey, 2013).

Giving more autonomy and control to the students who learn with the Flow Theory principles in the experimental group might be another reason for the result that these students had higher retained maths scores than the control group. However, in some studies in the literature, there are findings revealing that the curricula approved by MoNE do not sufficiently support students' autonomy (Kaya, 2018). In the literature, there are two different views on the relationship between learner control and variables such as engagement, achievement, satisfaction, retention, etc. While one of them claims that learner control increases the engagement of learners by enabling them to make decisions about their own learning, others argue that giving learner control will

negatively affect the retention of knowledge, since it has not been sufficiently proven yet how much control should be given to learners (Karim & Behrend, 2013). However, in the study conducted by Orakcı and Gelişli (2019), results supporting the findings of the current study were obtained. The researchers stated that learning activities based on student autonomy enabled students to achieve higher retention scores than the control group in the English course. Similarly, Alsharari and Alshurideh (2020) found out that the learner autonomy affected positively the retention scores of the learners.

5.1.2. The effect of instruction designed based on Flow Theory and RME approach on flow, boredom and motivation.

In the present study, the results demonstrated that the Flow Subdimension, Boredom Subdimension, and Motivation scores of experimental and control groups somewhat differed significantly. That is, there was a significant difference between posttest FSD scores of experimental and control groups in favor of the experimental group. In addition, the results of the study indicated that the instruction in the experimental group had a significant effect on FSD scores of the subjects on posttest compared to pretest. Additionally, the results revealed that experimental group had significantly lower BSD scores on posttest compared to pretest. The results of the current study also indicated that the experimental group's posttest motivation scores compared to pretest scores were greater than that of control group.

In the literature about Flow Theory, there are many studies that both support and contradict the results of the current study (Alperer, 2005; Bourgeois, 2012; Chan & Ahern, 1999; Engeser & Rheinberg, 2008; Esteban-Millat et al., 2014; Heine, 1997; Inal and Cagiltay, 2007, Latz, 2012; Middleton, 1995; Üzel, 2007; Rogatko, 2009; Santosa, 2015; Schweinle et al., 2006; Zheng, 2012). For example, the study conducted by Heine (1997) determined that the students who benefit from the instruction which is offered with more complex facilities related with Flow Theory (such as social interaction, student autonomy, giving students the right to choose, high-level cognitive requirements for challenging tasks) had higher levels of flow state than other students. However, Zheng (2012) investigated the flow experience of fifth grade students in an instruction of science course designed by game-flow elements. The results of the study

indicated that although the experimental group students had high flow experience after the treatment compared to before the treatment, the flow experience scores of the control group and experimental group students did not show a statistically significant difference.

However, in the literature on Flow Theory, there is rarely a study examining the boredom dimension separately (Pekrun, Goetz, Daniels, Stupnisky, & Raymond, 2010), since academic boredom has been a neglected subject that does not find enough place in the literature (Robinson, 1975; Sharp, Hemmings, Kay, Murphy, & Elliot, 2017). In the study conducted by Eryılmaz & Mammadov (2016a), it was determined that Flow and Boredom Subdimensions were negatively correlated, and it was observed that while the scores of one dimension increased, the scores of the other dimension decreased. In the current study, it was observed that the students in both groups already had a low level of boredom even before the experiment. According to Flow Theory, the state of boredom occurs when skills are much greater than opportunities for using them. In addition, the boredom results when the ratio between the complexity and skills change due to three factors: the type of activity, the phase of the activity and the role of the participants during the activity (Csikszentmihalyi, 1975).

There could be several reasons for the results that obtained in the current study. First, providing a balance between the challenge level of the tasks and the skills of the students might be a factor in these results. In the literature, there are studies which argue that the balance between skills and challenge can increase the affective features (Egbert, 2003; Esteban-Millat et al., 2014; Heine, 1997; Inal & Cagiltay, 2007; Huang et al, 2018; Kiili et al., 2012; Kirchhoff, 2013; Rha, Williams & Heo, 2005; Rheinberg & Vollmeyer, 2003; Santosa, 2015; Schweinle et al., 2006; Sedighian, 1998; Weiss, 2015). Especially, the use of activities very close to or slightly above the skill level of the students might have been effective in the emergence of positive emotions. The challenge of these activities was increased with the help of the questions posed by the teacher or decreased through the tips and feedback provided by the teacher and/or group mates, during cooperative learning of students. Thus, students' motivation towards mathematics might be increased, which is in line with the results of the study

conducted by Schweinle et al. (2006). The researchers found out that using flow elements (such as the balance between challenge and skill, supporting self-efficacy, providing positive affect and value for mathematics) enhance the motivation of learners during the instruction. Similarly, according to the study conducted by Santosa (2015), it was determined that the perceived skill and challenge levels positively affect the students' attitude and participation towards an online tutorial activity.

In addition, the results obtained from the study conducted by Esteban-Millat et al. (2014) revealed that the challenges in a learning environment were effective in the emergence of flow. Researchers also argued that the challenge of tasks/activities causes a sense of flow by affecting individuals' perception of passing time that is different from normal, and the level of concentration. Additionally, Inal and Cagiltay (2007) investigated the flow experiences of children in an interactive social game environment. The researchers found out that the complexity elements and challenge of the tasks had the most important role for increasing flow experiences of students. Moreover, Weiss (2015) found out that engagement and flow experience of participants increased when the learning activities were appropriate for them and their perceived skill level was flexed by challenging tasks. Similarly, in the study conducted by Hamari et al. (2016), the effect of flow (through challenge and skill balance) on learning during a game-flow instruction environment was investigated. The results of this study have revealed that both the challenge of the task and the skill of the learner have a significant positive effect on engagement and immersion of the students during the lesson.

Another reason for the result that the instruction applied in the experimental group had affected motivation, flow and boredom scores may stem from the autonomy provided to the students in order to make their own decisions and share their ideas, as well as the sense of control provided in carrying out their own actions. In the current study, students in the experimental group were encouraged to take their actions in many ways. There are several studies which found out that learner autonomy affects flow experience and motivation in a positive way (Borovay, 2007; Bourgeois, 2012; Egbert, 2003; Esteban-Millat et al., 2014; Heine, 1997; Joo et al., 2013; Middleton, 1995; Shernoff et al., 2003; Weiss, 2015). Middleton (1995) investigated the view of students

and teachers about what motivates them in mathematics classroom. The results obtained from the study have shown that most of the teachers do not give learners much opportunity to make their own choices during mathematics classes. The results obtained from the study conducted by Egbert (2003) showed that students' control over the given tasks and activities enabled them to experience flow in a foreign language class. In addition, Esteban-Millat et al. (2014) examined the effect of flow on learners' behavioral processes in virtual learning environments and determined that the feeling of being able to control their own actions was effective in entering the flow state. In fact, it was indicated that the more control they acquire, the higher concentration and absorption, which are the basic elements of the flow state, they will have.

Similarly, in their study, Joo et al. (2013) investigated whether perceived autonomy, competence and relatedness predict learning flow of adult learners who participated a Chinese learning course. The results of the study demonstrated that learning flow was significantly predicted by autonomy, competence and relatedness. In another study emphasizing learner control and social relations together, supporting the results of the current study, Shernoff et al. (2003) stated that students engage more during a group work than lecture instruction, because group work gives students a greater sense of control, while lecturing gives teacher a sense of control. The results of the study conducted by Weiss (2015) has revealed that adolescent students' engagement and experience of flow increased especially when they have control of the learning environment, the learning activities were appropriate for them and their perceived skill level was flexed by challenging tasks.

Another reason for the results obtained in the present study might be encouraging positive affect during the experimental process. In the current study, the teacher tried to provide empathy and to create a warm, friendly and sincere environment in the classroom, ensuring that the students trust the teacher and each other. Additionally, the teacher allowed some humorous elements and fun to be used in the classroom about the stories used in the activities and in the language used by the teacher without going beyond the topic. For this reason, the students never hesitated to ask for help from the teacher and their friends when they did not understand, and they did not worry about failing. The pupils in the experimental group were not evaluated for their opinions and

answers to the questions, and they did not encounter any external reinforcement or punishment for their answers. On the contrary, they were made to feel that even wrong answers were an opportunity for learning. More attention was paid than usual to ensure that the students were as warm and friendly as possible, especially when expressing their ideas and participating in the discussions. Comforting encouragements were often used so that students do not fear of giving wrong answers.

There are several studies in relevant literature that support the use of positive affect might enhance motivation and flow state (Deci et al., 1999; Esteban-Millat et al., 2014; Latz, 2012; Middleton, 1995; O'Hanlon, 1981; Robinson, 1975; Schweinle et al., 2006). For instance, the results obtained by Esteban-Millat et al. (2014) revealed that the attitude of the instructor was effective in the learners' experience of flow, as it influenced the focused attention principle of the flow experience. In other words, the researchers stated that students experience more flow in a learning environment where the teacher reinforces positive emotions, establishes a friendly relationship with the students and helps them whenever they need, which is in line with the current study. Additionally, according to the research conducted by Latz (2012), the use of elements related to positive emotional approach in the classroom environment was effective in students' entering the flow state, as in the current study. The same researcher also reported that the emotional state of the teacher in the classroom has the contagion effect to the students, that is, factors such as posture, gestures, language and tone of voice affect the flow of students. The use of positive humor elements in the classroom and feedback enabled more flow experience. At the same time, factors such as the teacher's close interest in students' extracurricular activities, solidarity with them, and gaining their trust, safety, and communication also had an impact on the students' flow experiences.

Similarly, Schweinle et al. (2006) revealed that the use of humor creates a fun environment in the lesson, allowing students to experience more flow. However, in some studies in the literature, it has been determined that in classrooms with high boredom behavior, teachers have a more pessimistic views towards students, report negative opinions about their education life, and show less sympathy towards such classes (O'Hanlon, 1981). In the present study, the teacher always made the students

in experimental group feel that they were valuable and know that the important thing is not to answer correctly, but to understand the subject. The positive affective manners of the teacher, which was also reflected in the qualitative findings that discussed in the following sections, may have enabled the students to be more interested and participatory towards the lesson, and therefore not to be bored. Supporting this result, Robinson (1975) determined that more boredom was observed in the classrooms where the teachers did not show enough interest in the students and the lesson they teach. Engeser and Rheinberg (2008) stated that the intrinsic motivation of learners might be hindered in self-threatening learning environments. Additionally, Deci et al. (1999) indicated that controlling elements dominated by the teacher cause learners to feel pressure on them, thus reduce intrinsic motivation. In another study supporting this finding of the present study, it was determined that teachers' support of positive affect in the classroom increased student motivation (Schweinle et al., 2006).

One reason for the results obtained in the current study might be interaction and cooperative learning that experimental group received. In the present study, experimental group students were directed to group activities that carried out with cooperative study and encouraged to interact with their friends during the activities, discussing and sharing their ideas with them, and asking for feedback from the teacher and friends, which might affect their flow state positively. During the teaching in the experimental group, it was frequently imposed by the teacher that doing mathematics should be interpreted as discussing and sharing opinions with peers. However, the findings obtained in the study by Kaya (2018) revealed that the objectives in the curricula approved by MoNE are insufficient in improving the interaction competencies of the learners. When the relevant literature is examined, some studies state that students' interaction with their peers and teachers, and their participation in learning tasks with their peers positively affect the flow experience, intrinsic motivation and decrease of boredom (Ak Şentürk, 2010; Alperer, 2005; Armstrong, 2008; Bourgeois, 2012; Efe, 2011; Heine, 1997; Inal & Çağiltay, 2007; Önce, 2020; Rathunde & Csikszentmihalyi, 2005a; Sawyer, 2015; Shernoff et al., 2003; Üzel, 2007; Yıldırım, 2019). For instance, the findings of the study conducted by Armstrong (2008) revealed that the students who interpreted doing mathematics as a process of discussing, understanding, and sharing with their peers had more group flow than the

students who cared about extrinsic goals, who interpreted doing mathematics as reaching the correct answer and obtaining written answers to the questions faster. According to Sawyer (2015), in a group study, if all group members contribute equally to the product, listen to each other's ideas sincerely, and group members have the autonomy to express their opinions, the level of group flow increases instead of getting bored.

In the current study, all activities were designed in such a way that they could learn cooperatively and study in groups. An effort was made to help them learn mathematics through social interaction, since the interaction of students with each other and with the teacher is an important part of the teaching processes in RME. In line with the results of the present study, Inal and Cagiltay (2007) have revealed that the motivation of students was higher in studies conducted with a group compared to individual studies. Similarly, Alperer (2005) determined that group activities were more effective on students' emotional motivation than individual activities. In their study, Rathunde and Csikszentmihalyi (2005a) revealed that students who spent more time studying with peers on several projects, attending in active and collaborative tasks had higher motivation and fun than students who spent more time in passive listening such as lecture and note-taking, or watching educational videos. However, in the study conducted by Liao (2006) which examined the effect of flow elements on the emergence of flow experience in a distance learning environment at university level, slightly different results were obtained from the finding of current study. Although the importance of interaction was emphasized in the study, when this interaction was among students, it did not have a significant effect on the flow experience of students. In the interaction between student-teacher and student-interface, a significant effect was observed on students' flow experiences.

It has been mentioned before (in the method chapter) that the application of Flow Theory principles alone in instruction may not influence the affective characteristics of learners, and that these principles should be considered holistically as much as possible. Therefore, the effect of social relations and collaborative work on increasing positive emotions depends on the provision of other flow dimensions. Findings obtained from the study of Schweinle et al. (2006) support this notion. The researchers

found out that the same positive affect was not observed in every classroom environment where social interactions were supported. For example, in the classrooms where students were threatened by the teacher in order to ensure cooperation; the positive affect, the importance given to the course and the challenge of the tasks were found to be low compared to other groups.

Another reason why the instruction in the experimental group was more effective on the posttest scores of the Flow Subdimension might be that the teaching in the experimental group attracted the interest of the students, made them see the mathematics lesson as important and enabled them to have more engagement in the activities. As expressed by Keller and Bless (2008), the harmony of the individual's personality and the structural characteristic of the assigned task have a great effect on the emergence of the flow state. The experimental group students participated in learning processes based on activity and reality, which are the basic principles supported by RME approach. These activities are important both to attract students' attention and to emphasize the importance of mathematics subjects. The activities applied in the experimental group and the use of RME, the opportunity to see concretely in which situations mathematical concepts could be used in daily life, may have been effective in realizing this result. Since the RME approach provides mathematics teaching by solving real-life problems starting from the application stage of the subjects, it both attracts the interest of students and ensures that they care about mathematics (Altun, 2006; Can, 2012; Üzel, 2007).

There are several studies in the literature that deal with the effect of learner interest and the importance given to the subject, and show that emphasizing and facilitating students' interests increase the positive perceptions of students towards school environment, their teachers and friends, including motivation and flow state, while decrease the level of boredom (Altıntaş et al., 2010; Annetta et al., 2009; Çakır, 2013; Engeser & Rheinberg, 2008; Keller & Bless, 2008; Kirchhoff, 2013; McQuillan & Conde, 1996; O'Hanlon, 1981; Rathunde & Csikszentmihalyi, 2005a, 2005b; Robinson, 1975; Schweinle et al., 2006; Üzel, 2007; Yetim Karaca & Özkaya, 2017). For instance, Kirchhoff (2013) found out that flow-like experiences provide students to engage in reading activities when they are interesting and appropriate with the level

of learners. Similarly, McQuillan and Conde (1996) pointed out that the reading texts that provide the flow experiences mostly consist of contents covering the field of interest and compatible with the skill/knowledge level of the subjects. In addition, Altıntaş et al. (2010) investigated dispositional flow of participants in terms of several variables. They stated that the frequency, length, and type of activity involvement have effect on some of the flow elements, such as concentration, control, competence, and intrinsic enjoyment of participants. Additionally, in the study conducted by Engeser and Rheinberg (2008), the flow experiences of students who participated in several activities with different importance levels were examined. Thus, findings were obtained showing that the importance of learning activities by the learners increases the flow experience. Accordingly, it has been shown that highly important activities enable individuals to experience flow even if the skill level of the activity exceeds the level of challenge.

Additionally, fifth grade students might enjoy playing games and be interested in games due to the needs and developmental characteristics of their age level. Therefore, the fact that students see the learning activities as a game may have increased their interest and engagement in these activities, enabled them to have fun while doing them, and increased the flow state and motivation scores while decreased the boredom level. There are some studies in the literature which show the effect of the game on the flow state. According to the results of the study conducted by Annetta et al. (2009), flow-producing learning activities such as games had significant effect on students' engagement, which is in line with the findings of the present study. Moreover, the results of the study conducted by Zheng (2012) revealed that students who learn with the games which supports the principles of Flow Theory, learn the science subjects better and with fun. Rathunde and Csikszentmihalyi (2005b) found out that the students who learn in the Montessori School environments, in which didactic methods are avoided and active participation with relevant content is aimed, had greater intrinsic motivation, flow experience and undivided interest during activities compared to students who learn in traditional school. In another study, Schiefele and Csikszentmihalyi (1995) found out that the interest had significant relations with variables such as intrinsic motivation, potency, self-esteem, importance and the perception of skill. Additionally, the study conducted by Yetim Karaca and Özkaya

(2017) have shown that RME-based instruction provided higher motivation in the experimental group than the control group. However, the study conducted by Cengiz (2020) indicated that RME-based mathematics instruction did not have any effect on the motivation scores of experimental group, while the control group decreased their motivation scores on posttest compared to pretest as in the present study.

As O'Hanlon (1981) stated that boredom behavior occurs suddenly, as a result of frequent encounters with a situation that individuals are used to. However, the activities applied in the experimental group may have reduced the boredom behavior of students since they included learning scenarios that students did not experience before. Furthermore, the learning activities may have attracted students' interest as they provided real-life examples using the principles of RME approach. In the study conducted by Robinson (1975), it was determined that useless and uninteresting school subjects were closely related to students' boredom states. However, Flow Theory-based mathematics teaching might have made students less bored as they learn by experiencing how mathematical concepts can be useful in daily life. In line with this result of the present study, Schiefele and Csikszentmihalyi (1994), have revealed that the interest of learners was a significant predictor of the intrinsic motivation, quality of experience and grades in several courses including maths. Similarly, the study conducted by Chan and Ahern (1999) examined the effect of content relevance of the activity on motivation of learners. The results revealed that the content of the activity had a great effect on motivation. Moreover, the results of Ak Şentürk's (2010) study have revealed that the interest, autonomy, focus and the challenge levels students have on the activities had significant effect on their emotional motivation. However, in the study by Zakaria & Syamaun (2017), the results indicated that mathematics teaching according to RME did not cause any difference in the attitudes of the experimental and control groups towards mathematics. Similarly, the results of the dissertation study conducted by Korkmaz (2017) have shown that the attitudes of students towards mathematics lesson were statistically different to the detriment of experimental group in which RME based instruction was applied.

One of the reasons for the results of the current study might be the extensive use of immediate feedbacks that enable the students to elaborate and clarify their answers in

the instruction applied in experimental group. In the literature, there are several studies stating that using immediate and effective feedback supports affective features (Bourgeois, 2012; Csikszentmihalyi, Abuhamdeh, & Nakamura, 2005; Schweinle et al., 2006). For example, in the study conducted by Schweinle et al. (2006), it was concluded that students in classes where feedback was used frequently reported higher level of efficacy and importance of the course than students in other classes. Deci, Koestner and Ryan (1999) states that the form of the feedback, the way it is perceived by the students, and whether it is informative or not is important. That is, while autonomy-supportive feedback increases motivation, feedback perceived as controlling may even lead to a decrease in student motivation. Thus, the teacher must have provided the motivation of the students towards the mathematics lesson by ensuring that they obtain the necessary messages when they needed.

5.1.3. The effect of instruction designed based on Flow Theory and RME approach on anxiety subdimension scores.

The results of the study indicated that there is no significant difference between two testing times of Anxiety subdimension for the experimental and control groups. In the present study, Anxiety subdimension scores of both the experimental and control groups showed similar changes in the pretest and posttest. Although the mean scores of the experimental group on Anxiety subdimension decreased in the posttest compared to the pretest after the experimental process, this decrease did not make a significant difference. Similarly, control group students' mean scores on Anxiety subdimension slightly decreased in the posttest compared to pretest, but this decrease did not make any significant difference either.

In the literature, there are several studies which determine that there exists a negative relationship between anxiety and flow dimensions. For example, in the study conducted by Eryılmaz & Mammadov (2016b), a moderate negative correlation was found between Anxiety and Flow dimensions. In addition, Koehn (2013) reported that the symptoms of anxiety might cause a negative suppressing effect that prevents the emergence of flow.

The reason why there was no significant difference in the Anxiety subdimension scores of the experimental and control groups may be that both groups already had a low level of anxiety even before the treatment process. When we look at the relevant literature, it can be said that the findings obtained from the study conducted by Franke and Bogner (2013) on the situational emotions (interest, well-being and anxiety) of high-school tenth grade students in the gene technology course are in line with the results of the current study. Accordingly, there was no significant difference between the anxiety levels of two groups, and the students of both groups showed a very low level of anxiety. Additionally, Chen and Pan (2015) stated that the anxiety of students in learning foreign language negatively correlated with the autonomy, which supported by flow-based instruction during the tasks. Unlike the findings of the present study, in the study conducted by Rogatko (2009), the group with higher flow scores showed a greater decrease in negative emotions compared to the other group which had lower flow scores.

The instruction level applied in both groups and the challenge level of the activities might not have exceeded the skill levels of the students excessively. The anxiety is a concept that arises in situations where a very high level of challenge and a low level of skill coincide (Csikszentmihalyi, 1975; Csikszentmihalyi & Nakamura, 2014; Whalen, 1997). However, Egbert (2003) states that a certain amount of anxiety and stress should be present in order for students to experience flow. According to Flow Theory, the sense of anxiety functions as a mechanism that regulates whether actions are done correctly. The individual realizes that it is going well if he feels the control of his actions, whereas the awakening of anxiety immediately indicates that it is getting worse and needs to make adjustments. Thanks to this feedback cycle received by the individual during the activity, the individual is forced to improve his skills and enters the flow channel again by getting out of the anxiety state (Csikszentmihalyi, 1975). Tramonte and Willms (2010) have obtained results that support this situation in their study on the presence of anxiety in individuals between the ages of 6-12. Accordingly, the highest anxiety occurred in individuals with low-skill in activities with high-challenge. They also determined that perceived skill level had more risk factor than the level of challenge in an activity.

5.1.4. The discussion on opinions of experimental group students about the instruction

In this study, the opinions of fifth-grade students about mathematics instruction in line with the principles of Flow Theory were investigated. The qualitative data were analyzed through thematic analysis as mentioned in data analysis part of the method in the previous chapter. The opinions of experimental group students have revealed that they generally expressed positive opinions about the teaching process and activities. In relevant literature, it is seen that the opinions of the participants about the teaching activities in terms of Flow Theory and motivation were examined in similar categories or themes (Miles, 2012; Montanez, 2011; Önce, 2020; Pearce, 2004). In the present study, the opinions of students include the characteristics of mathematics instruction and the characteristics of the teacher who performed the teaching. Additionally, the students mentioned that the instruction had effects on their cognitive, motivational, and social aspects.

First of all, when describing the characteristics of the mathematics instruction, it has been stated that mathematics instruction based on Flow Theory principles has a challenge in accordance with the perceived skills of the students. According to the results of the thematic analysis of the data obtained from the interviews, observation notes and student diaries, most of the students stated that the activities applied in the lessons had a medium challenge; while a few students stated that these activities exceeded their level. Thus, the students were able to see their own progress and stated that they were more motivated to participate in the lesson. This view coincides with the study conducted by Inal and Çağıltay (2007), which indicates that the students who did not feel any challenge during the game activities could not experience the flow state. In addition, Bianca (2000) concluded that the more an instruction is compatible with the learning speed of the students, interactive and challenging, the more likely students' engagement increase in the lesson, which is in line with the findings of the present study. As Csikszentmihalyi (1985) stated that if individuals' skills and challenging activities are balanced on an above average level, then they feel most positive about the experience, since they operate with their fullest capacity.

Another characteristic expressed by students is that mathematics instruction designed according to Flow Theory and enhanced with RME has clear goals. The data obtained from the interview and observation reports showed that the students understood the purpose of the lesson and the activity clearly, thanks to the teacher's explanations, the exchange of ideas among the students and the clear expression of the activity instructions. One of the most important conditions of flow state is that the purpose or goals are clearly and realistically determined (Csikszentmihalyi, 1990). Mannell and Bradley (1986) demonstrated that the participants experienced more concentration during tasks with clear goals, which is consistent with the assumption made by Csikszentmihalyi and Rathunde (1993) that flow experience is more likely in activities in which the goals are clear and understandable. Additionally, Schere (1998) found out that classroom activities that have clear goals help students to experience flow state and positive mood. Similarly, Meyer and Jones (2013) stated that a teaching activity has clear goals as one of the factors that ensure course satisfaction of university students. The results of the study conducted by Sillaots (2014) have found out that the goals are clear in teaching activities based on Flow Theory.

Another finding obtained from the thematic analysis of qualitative data was that students were able to receive clear and instant feedback in mathematics teaching where Flow Theory principles were used. Thanks to these feedbacks, the students stated that they easily learned the points they did not understand, so that they could make progress during the activity. They also stated that they were able to cooperate more with their friends and increase their communication between them. In line with this result, Sillaots (2014) demonstrated that the students were able to get enough feedback whenever they needed it, during the instruction which included the principles of Flow Theory.

The thematic analysis results show that students are free to make their own decisions and express their opinions in the classroom, and therefore, mathematics instruction designed according to Flow Theory supports students' sense of control and autonomy. This is also in accordance with the literature (Ke & Abras, 2013; Meyer & Jones, 2013; Schweinle et al., 2006; Turner et al., 1998). Students' sense of control and autonomy might have enabled them to fulfill their own responsibilities, to engage more in the

activities, to take the floor in group and intergroup discussions and not hesitate to express their opinions. According to Deci and Ryan (1987), giving the control to the students is a central principle of intrinsic motivation to learn, while the control of teacher causes lower motivation. In support of this finding of the present study, the results of the study conducted by Griffiths (2016) determined that giving students autonomy and control about their working styles in assignments and providing a positive relationship with the teacher provided them more intrinsic motivation. In the study conducted by Ke and Abras (2013), it was determined that providing individuals with special learning needs the opportunity to define their own identities and allowing them to determine the process steps during the tasks or games created a sense of autonomy for the participants, as in the design of the instruction in this study.

The students who learn with the mathematics instruction designed according to the Flow Theory principles mentioned that this course aroused their interest. The materials used in the course, activities, technological support and visuals, physical activity and real-life examples suggested by RME may have influenced this view of the students. Students stated that they were worried about some units or topics that they were not good at in mathematics before, but they found mathematics interesting and entertaining thanks to the activities they participated in. The study conducted by Schiefele and Csikszentmihalyi (1995) had results that support these findings. Similarly, in line with the finding of present study, Korkmaz (2017) found out that the instruction carried out according to RME is found more fun, interesting and preferred by the students. In addition, in the dissertation study conducted by Altaylı (2012), students expressed that RME-supported instruction increased their interest in the lesson, helped them feel happy and enjoy the lesson. In the present study, the students stated that they felt as if they were living the situation in real life while doing some activities, which attracted their attention. Similarly, the study conducted by Inal and Çağiltay (2007) revealed that students feel as if they live in the environment while they participate in the activities that attract their interests, such as games. Additionally, the study of Miles (2012) indicated that interest was obtained as the most effective prerequisite for the emergence of the flow state. Whalen and Csikszentmihalyi (1991) stated that having the opportunity to choose helps students develop sustained attention, process-oriented skills, and identify their interest. Turner et al. (1998) determined that

the teacher in the high-participation classroom taught with interesting content in a way that would interest all students in mathematics, while the teachers in the low-participation classrooms aimed to reach the correct answers or achieve a grade. In the study conducted by Çakmak et al. (2015), the flow state of doctoral students was examined, and according to the data obtained from the interviews, it was seen that interest in the field emerged as an important theme in the study, which is line with the present study. Lastly, as a result of the interviews conducted with the teachers, Ak Şentürk (2010) determined that the subjects attracted more interest of the students because they were similar to real life, which contributed to the students' willingness to participate more in the activities.

While the students expressed their opinions about the mathematics lesson, they also talked about the characteristics of the teacher who carried out the lesson. According to the students, the teacher reflected positive affects during teaching. That is, the students mentioned that the teacher, whom they described as very kind, tolerant, patient, and sympathetic, also had a fun personality and loved them. This result of the present study is supported by the study of Schweinle et al. (2006), which indicated that teachers' characteristics such as using positive affect, showing sensitivity and kindness towards students help to increase the enjoyment and interest towards mathematics lesson. Accordingly, students taught by different teachers stated that teachers employ different levels of positive affect, and it was observed that students in the classroom where positive emotions were supported at a higher rate indicated higher mathematics motivation. Additionally, the qualitative results of the study conducted by Turner et al. (1998) indicated that the teacher of the high-participation group softened students' frustrations when they had difficulty by using humorous elements in the classroom. However, in the low-participation group, the teacher took over the operations for the students without giving them to struggle, implying that many of the students would not remember it.

In addition, students mentioned that the teacher had a good teaching technique, that she taught effectively and fluently, and constantly encouraged them to express their thoughts without any hesitation, to involve in discussions, which helped students learn better than the previous teaching style before the experiment. In addition, the thematic

analysis results showed that the teacher frequently asked questions that required students to explain the answers of other students in the class and validate their ideas, which was seen by students as one of the elements that ensure effective teaching. In the literature, there are studies showing that teachers use different techniques in order to provide effective teaching (Ak Şentürk, 2010; Jiang, 2014; Schweinle et al., 2006; Turner et al., 1998; Yılmaz, 2019). For example, the result of the current study is in line with the study of Schweinle et al. (2006). In addition, the results of the study conducted by Jiang (2014) are parallel with the result of current study, indicating that the students interpreted the teacher asking questions as an effective teaching method because all students have to actively participate in answering the questions. Similarly, according to the dissertation study conducted by Yılmaz (2019), students' ideas and real-life examples are among some of the tools that lead teachers to ask questions for the purposes of guiding, probing and factual questioning. These probing of the teacher might help to increase task importance and social interactions among the students, as they try to answer each other's questions, and contribute to effective teaching. In her dissertation study, Ak Şentürk (2010) determined that the group in which classroom discussion was used as a teaching technique had more flow experience.

Moreover, experimental group students expressed that the instruction they received contributed to their motivation in terms of both intrinsically and extrinsically. The intrinsic motivation elements used by the students coded as autotelicity and effort, as expressed in the Flow Theory literature. Firstly, while explaining the reasons for participating the mathematics course developed based on flow principles, the students referred to the autotelic nature of the course and used expressions implying that they participated in the course for its own sake. This seems to imply that students attend an activity just for doing that activity, rather than an external benefit (Csikszentmihalyi, 1990a). In other words, if someone experience flow in an activity, he will want to repeat it again in order to have a similar experience (Csikszentmihalyi & Rathunde, 1992). In terms of this theme, students stated that the mathematics lesson was quite fun for them, it made them feel good, they liked mathematics and they enjoy in this lesson. Additionally, they expressed that they wanted to participate in these activities again and wished this learning style to continue. They also stated that they have never had the thought of *I wish I was doing something else right now* during the lesson. These

results are consistent with the study of Schweinle et al. (1999). At the same time, the students stated that they often did not experience feelings such as boredom and anxiety in this lesson, which is a finding that supports the results that the students' boredom and anxiety levels are low as revealed by the quantitative findings.

The thematic analysis results indicated that Flow Theory-based mathematics instruction increased students' effort to learn mathematics. They were more motivated for increasing the time they spent to cope with the difficulties they encountered in learning mathematics and to learn mathematics by themselves outside the classroom, even if they were not told by the teacher or given homework to complete at home. Deryakulu (2002) states that students with internal locus of control make more effort to fulfill their learning tasks and are more motivated than those with external locus of control in a learning activity. Additionally, according to Subaşı (2000), the continuous effort made to learn a lesson and the responsibility of learning are indicators of the motivation of the student. In the study conducted by Oğuz (2008), pre-service teachers' views on learning were examined, and some of the students stated that learning is more dependent on effort than ability. In other words, if a student's effort to learn a lesson increases, the probability of learning that lesson will increase even if they have low level of ability in that lesson.

The thematic analysis also indicated results related to extrinsic motivation, although not as much as intrinsic motivation results. Some of the students, while expressing their thoughts on mathematics instruction based on Flow Theory, mentioned extrinsic motivation factors. For example, when the students were asked what motivates them more in these lessons, it was observed that they gave answers such as exams and gaining the appreciation of their teachers and friends. According to studies in the literature, the flow of individuals varies according to the type and content of the activity and can be experienced in different time periods. In this case, it is not possible for the students to be in a flow state throughout whole course period. In such cases, individuals may need some external orientation to motivate themselves. In fact, there are studies showing that the appropriate use of extrinsic motivation before teaching a behavior for the first time might have a positive effect on learning (Gürdoğan, 2012; Ryan & Deci, 2000).

The present study also indicated that the mathematics instruction applied in the experimental group contribute to cognitive efficiency of students in mathematics. When the effects of the applied teaching method to learning is examined, it is seen that the activities included in this teaching enable students to learn while having fun, enable effective learning, help students concentrate and focus on the activities deeply, and provide immersion for them. According to the thematic analysis results, students who learned in the experimental group stated that they enjoy learning mathematics during the activities they performed in the class. The students stated that while they thought that learning mathematics was difficult or boring, they realized that it was actually possible to learn it in a fun way. Thus, they could get rid of their prejudices about mathematics thanks to these activities. In addition, based on the qualitative findings, it is possible to say that Flow Theory-based instruction enabled students to learn mathematics effectively. Experimental group students who learned with this instruction stated that they learned more easily than before and corrected their existing erroneous knowledge or misconceptions through cooperative study. In addition, they reported that what they learned was more long-lasting, and they were able to transfer what they learned to other fields and increased their time to solve mathematical problems on their own. These findings appear to be consistent with quantitative findings, discussed in previous sections.

The thematic analysis results revealed that instruction based on Flow Theory principles helped students have intense focus and concentration on the activities and the subject during the lessons. This result of the present study is in agreement with the results of the study conducted by Inal and Çağiltay (2007), which presented that the students who have flow experience during an activity were absorbed deeply, did not care about the things which happen around, and they mainly focused on the task in order to pass the next level. It can be thought that cooperative study might be effective in obtaining the results of students experiencing intense concentration during the activities, because the students tried to interpret and analyze the different thoughts of their friends in the groups and to produce solutions by gathering up these differences. In accordance with this finding, Sawyer (2015) stated that in heterogeneous groups where members have different characteristics, individuals constantly feel the need to concentrate on the thoughts of their teammates, interpret them and update their own knowledge.

In addition, students experienced the feeling of immersion, which is defined in the Flow Theory literature as the loss of self-consciousness and the feeling of not being able to understand how time passes (Baños, Botella, & Raya, 2005; Sillaots, 2014). The experiences related to this concept expressed in the interviews, observation notes and student diaries can be shown as one of the most prominent outputs that describe the flow state (Csikszentmihalyi et al. 2017) experienced by students in the activities. In the current study, some students mentioned that they forgot where they were during the activities, not only in time but also in the place they were in. This finding is consistent with the concept of *transformation of time* and *telepresence* obtained in the study by Guo (2004). This term was addressed to deep involvement that emerged as a result of the indication of telepresence with other flow elements as well. Additionally, Sillaots (2014) investigated the affective states of students in the research methods course in which the teaching based on flow principles was carried out. Accordingly, it was determined that the students experienced the emotions defined as immersion, that is, the time passed faster for them, they lost their concern about self at these moments and displayed a highly participatory attitude, which shows similarity with the result of the present study. In the study conducted by Altaylı (2012), students who received RME-supported instruction stated that they could not understand how the time passed, as they were happy and enjoyed in the lesson. In the present study, the students in the experimental group were so immersed during the activities that some students stated that they did not realize how the lesson ended while thinking about the activity, while some others stated that they forgot to take a break between lessons. This result is in agreement with the results of Zollars (2017). Accordingly, the group interacting with the flow components in a more complex structure was observed to have a higher focus and a sense of time passing faster. Students did not want to leave the class for the break and focused on their tasks. According to the study conducted by Inal and Çağiltay (2007), students were so immersed in the game during the flow situation that they did not even respond to their groupmates' requests for help.

Thematic analysis results also revealed that mathematics instruction based on Flow Theory principles has some social effects. However, students mentioned both positive and negative social effects of the instruction. The positive effects of the instruction in terms of social sense are the contributions it provides to the students regarding the

cooperative study and democratic attitude. According to the thematic analysis result, students stated that they learned how to cooperate, help and contribute each other's learning during the activities. The reason for this result might be that mathematics instruction applied in the experimental group was designed to be carried out with activities in which students interact with each other and the teacher, not for individual learning. Both immediate feedback, which is one of the basic principles of Flow Theory (Csikszentmihalyi, 1990a; Schweinle et al., 2006), and interaction, which is one of the basic characteristics of the RME approach (Heuvel-Panhuizen, 2000; Üzel, 2007), include helping each other, completing each other's deficiencies, and supporting their collaboration. Therefore, the activities implemented in this lesson can be considered as the source of students' ideas about cooperation.

There are many studies in the literature indicating that cooperative study, interpersonal interaction encourages motivation and flow. In the study conducted by Jackson (1995), the thematic analysis results indicated that positive team play and interaction play role in facilitating flow. In terms of the advantages of cooperative learning, Jolliffe (2007) stated that learning with peers and giving importance to cooperation result in greater social competencies and psychological wellness than competing with peers or individual study. As Inal and Cagiltay (2007) stated that the flow experiences occurred more among students while they participate in the group activities, and the interaction among participants increased after the group activities. The results of the study conducted by Rathunde and Csikszentmihalyi (2005a) have revealed that the students who study in the Montessori school, in which they have more chance for studying cooperatively, more often perceive their classmates as friends, reported more positive views of teachers and peers and more time spent in group work than the students in traditional school. As Csikszentmihalyi (1997) states, social interactions have many features of flow activities, and these interactions require a regular investment in mental energy. Thus, this communication and interaction established between individuals enables them to experience social satisfaction and improve their lives. In the study conducted by Armstrong (2008), it was stated that in environments where cooperative learning is supported, students can have discussions on each other's views, consequently this supports synchronized thinking and provides group flow.

During these cooperative studies, students might have been aware that they have equal rights in decision-making mechanisms within the group and everyone can freely express their own ideas. Therefore, these activities might help students become aware of concepts such as democracy and equality. In the fifth-grade Mathematics Curriculum, it is stated that the basic skills gained through education should contribute to the democratic development of individuals. In addition, within the scope of social and citizenship competences, it is emphasized in the curriculum that individuals should respect different ideas, democratic principles, and learn to compromise with other people (MoNE, 2018). These results of the current study are congruent with the relevant literature (Erbil & Kocabaş, 2018; Hendrix, 1996; Johnson & Johnson, 2015). In the study conducted by Erbil and Kocabaş (2018), the effect of the cooperative learning method applied to primary school 3rd grade students on the democratic attitude levels of the students was examined, and a significant difference was obtained. According to Hendrix (1996), since cooperative learning enables students to learn from each other, regardless of how different they are from each other, the learning environment becomes a place where the principle of democratic tolerance is realized.

On the other hand, it has been determined that the instruction applied in the experimental group has negative social effects, albeit to a lesser extent compared to the positive effects. According to the results of the thematic analysis, the experimental group students reported that they had disagreements with their friends in the group from time to time, and that they had conflicts because they could not agree on a common idea. The main reason for the emergence of such a finding may be that the students did not have enough experience in cooperative study since they had not learned through group studies, peer support, and constructive feedbacks before the experimental process. Therefore, they might have had difficulties in the distribution of tasks in the group, division of labor and to respect everyone's opinion when they contradict their own.

In addition, while the experimental group students were talking about the activities, they stated that sometimes the competition among the groups bothered them. There could be several reasons for this result. Firstly, the students were more accustomed to competitive teaching before the treatment, which was also used in the control group.

Secondly, due to the developmental characteristics of this age group, students' efforts to come to the fore may have led to this result. Especially primary school children may perceive helping each other as cheating because they do not have the background of cooperation. Therefore, cooperative study may not occur for all learners immediately in this age group, and it may take a long time for students to acquire this behavior (Jolliffe, 2007). However, İnal and Çağiltay (2007) state that interpersonal competition in game-assisted instruction provides a balance between students' skills and perceived difficulty level, minimizing the boredom and anxiety of individuals, and increasing their flow experiences. Additionally, Bourgeois (2012) observed that American students were taught in a more openly competitive school environment than German students, and American students showed more flow experience. According to Deci, Betley, Kahle, Abrams and Porac (1981), competition in the learning environment can function as a controlling and informative reward. Even if the competition elements provide flow state at that moment, they are estimated to harm intrinsic motivation in the long run.

Finally, the experimental group students made some negative statements about the physical environment. These include noise in the classroom during activities, and students' inability to see the blackboard and their friends in other groups adequately, due to crowded class and seating arrangement. The sound level that occurs during the activities should be acceptable up to a certain point, because group members occasionally discuss, share their ideas, and give feedback to their friends while working on the activities. The reason why students are negatively affected by this situation may be that they are not accustomed to this type of learning environment, as mentioned before. Before the experiment, the only person heard in the classroom was the teacher. While solving a question, the voices of those the teacher had allowed to speak could be heard, and the classroom was usually quiet. In addition, during cooperative learning, the current desk layout of the class is changed in line with group works, desks and tables are made to face each other so that group members can see each other, and students leave their own desks and move to their groups. Due to the crowded class, it can be difficult to maintain this order from time to time. Therefore, students might have expressed such a thought due to reasons arising from the seating arrangement. In line with this result, in the study conducted by Sillaots (2014) to

determine the effect of the teaching applied in the research methods course on the flow state, university students stated that they were disturbed by the excessive noise that occurred while discussing the given activities.

5.1.5. General summary for the discussion of the results.

When the quantitative and qualitative findings of this study are interpreted in general, Flow Theory-based instruction has enabled students to have a more long-lasting mathematics compared to instruction applied in control group. Since Flow Theory is basically a theory of motivation and is based on affective factors, it can be considered as an important result that mathematics instruction based on Flow Theory enabled students to achieve higher retention mathematics test scores. In addition, while teaching in control group did not have any effect on students' flow state, instruction in experimental group increased students' flow experiences significantly. In addition, mathematics instruction in experimental group increased students' motivation scores significantly more than the instruction in control group. The qualitative findings of the study also show that the students in the experimental group, who learned with Flow Theory-based mathematics instruction, generally reported positive opinions about this instruction. According to the results of the thematic analysis, the students talked about the qualifications of mathematics instruction and the teacher, and they reported that the teaching environment where these qualifications are met can provide some positive effects on students' motivation, cognitive and social skills. There are many studies in the literature showing that students do not like mathematics, are afraid of it, have low motivation in mathematics, believe that they will fail, and cannot succeed in this lesson (Aksu, 1985; Çakmak, 2005; Demirdöğen, 2007; Kennedy et al., 2008). On the other hand, there are also studies which argue that the main reason for this failure is not students' cognitive or intellectual abilities, but their affective and motivational characteristics (Csikszentmihalyi, 2014a). For this reason, it is thought that the findings obtained from this study are important in preventing the low motivation towards the mathematics course and the perception that it is difficult to learn mathematics. Some recommendations are listed in the following paragraphs in order to support future research on this topic.

5.2. Recommendations

In the following sections, recommendations were made in line with the findings obtained from the current study and the relevant literature, in order to use Flow Theory-based instruction more effectively in mathematics and other courses.

5.2.1. Recommendations for practice.

This study obtained results revealing that the instruction based on Flow Theory and enhanced with RME contributes to fifth-grade students in cognitive and affective aspects. The students in the experimental group achieved significantly higher posttest scores in terms of mathematics achievement, flow experience and mathematics motivation compared to the scores they obtained before the experiment. In addition, the mathematics motivation posttest scores of the experimental group students and the mathematics retention test scores were significantly higher than that of the control group students. The results obtained from both quantitative and qualitative data of the present study indicated that Flow Theory can provide a new lens for educators and practitioners in terms of designing instruction. Since this study is one of the first studies to use Flow Theory directly in an instructional design of mathematics course and to examine the results within the scope of an experimental study, it is thought to have made significant contributions to the literature. Therefore, the principles of Flow Theory used in this study and the characteristics of instruction can be recommended to practitioners in order to effectively design mathematics teaching environments. In addition, the Flow Theory can be considered by mathematics curriculum developers when determining learning objectives in terms of affective domain. Therefore, the following implications can be made for practice:

1. Flow Theory can be incorporated by educational researchers and mathematics teachers in fifth-grade mathematics teaching.
2. Teachers should use the principles of Flow Theory in mathematics teaching in order to ensure that students have motivation towards the mathematics course, participate in the lessons with pleasure and learn while having fun.

3. Students should be given a greater sense of control and autonomy during the lesson, and teachers should have the role of guiding the learning environment, not controlling it.
4. Teachers should provide an environment where students can share all kinds of ideas about the lesson. Thus, students' wrong answers should be turned into an opportunity for correct learning.
5. Mathematics teaching should provide interaction between students as much as possible. The teachers should design learning activities in which students can work collaboratively, develop skills such as division of labor, cooperation, and responsibility for their friend's learning. In order for these skills to be acquired from a very early age, students should be provided with cooperative work activities from the moment they start school.
6. In the mathematics course, attention should be paid to affective characteristics as well as cognitive skills of students. Positive emotions should be supported in the classroom among students and teacher-student interactions. Evaluations for grading and expressions containing a perception of threat should be avoided, and efforts should be made to create a warm and friendly atmosphere where learning is important.
7. Students should be encouraged to seek help from each other and from the teacher when they need it, and they should be provided with immediate and informative feedback on their answers.
8. Learning activities should have content that will attract students' interest, taking into account the demographic and developmental characteristics of students such as age, socio-economic level, and the region they live in, and should require the use of various equipment (concrete materials, technological tools, etc.). Hence, RME can be used to attract students' interest, to enable students to rediscover mathematical concepts based on daily life problems and to help them learn where these concepts can be used in daily life instead of simple memorization.

9. A balance should be maintained between the challenge level of the activities used in teaching mathematics and the perceived skill level of the students. The level of challenge must be equal to or slightly higher than the skill level of the students. Learning activities that are too difficult or too easy should be avoided, and this balance should be established by providing students with hints and feedback when necessary or asking them about the factors behind their ideas.
10. These aforementioned properties are necessary but not sufficient to ensure academic achievement, motivation and other positive affects in mathematics teaching. In order to achieve these, all the flow features should be used together and holistically as much as possible.

5.2.2. Recommendations for further research.

Considering the results of the current study, the following recommendations can be made for future studies:

1. This study is limited to fifth-grade students ($n = 73$) studying at one of the public schools in Bornova, Izmir. Further experimental studies can be conducted with other school settings and larger samples.
2. The future studies could be designed with all other grades of middle school levels (grades sixth to eighth) in order to investigate the effects of mathematics instruction developed based on Flow Theory on achievement, retention, motivation and flow state.
3. In order to examine the effects of Flow Theory in mathematics lessons in more detail, longitudinal studies can be planned starting from earlier grade levels, and comparisons can be made between the experimental and control groups.
4. In this study, the objectives and units in the curriculum approved by MoNE and in the weeks when the study was carried out according to the annual plan were investigated. In future studies, the effects of Flow Theory can be examined in different topics, units and learning outcomes.

5. Since Flow Theory is considered as a kind of motivation theory in the literature, its effects on academic achievement and motivation can be tested in other courses (such as science, foreign language etc.) where students have difficulties in terms of being motivated.
6. There are different findings about the antecedents and consequences of the flow state in the literature. Relational studies can be done by considering different variations of these antecedents and results, in future studies.
7. In this study, flow, boredom and anxiety, which are the dimensions expressed by the basic Flow Theory were discussed. In future studies, designs can be used in which the dimensions revealed by different flow models (e.g. the model of Massimini & Carli, 1998) are examined.
8. In this study, the data were gathered through self-report measures, observations and interviews in order to determine the students' achievement, retention, motivation and flow state in mathematics. In addition to the data collection tools used in this study, future studies could be conducted using methods such as the Experience Sampling Method which requires many measurements in the same time period and addresses the momentary opinions of the participants.
9. In this study, teaching activities were designed as suggested by Realistic Mathematics Education in order to apply the principles of Flow Theory in mathematics teaching. In future studies, different teaching methods and techniques (such as game-based, technology-supported teaching, etc.) can be used together with Flow Theory principles to make instructional designs and examine the effects of the theory.
10. In future studies, more comprehensive instructional designs can be made by considering other motivational theories (for example, Self-determination Theory) together with Flow Theory. The effectiveness of these instructional designs can be compared with the curriculum approved by MoNE by conducting experimental studies.

11. Random assignment was not possible because the groups in the study were already-intact groups, so a quasi-experimental method was used. Further studies can be conducted with random assignment of subjects.

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B. INFORMED CONSENT FORM

ARAŞTIRMAYA GÖNÜLLÜ KATILIM FORMU

Bu araştırma, ODTÜ doktora öğrencisi Yasin AY tarafından yürütülmektedir. Bu form sizi araştırma koşulları hakkında bilgilendirmek için hazırlanmıştır.

Çalışmanın Amacı Nedir?

Araştırmanın amacı, Akış Kuramı prensipleri temel alınarak yapılan bir öğretimin, öğrencilerin matematik dersine yönelik motivasyonlarına, akış durumlarına ve başarılarına etkisi olup olmadığını belirlemektir.

Bize Nasıl Yardımcı Olmanızı İsteyeceğiz?

Araştırmaya katılmayı kabul ederseniz, sizden Matematik Testi, Matematikte Akış Ölçeği ve Matematik Dersi Güdülenme Ölçeği'ni cevaplamanızı isteyeceğiz ve cevaplarını yazılı biçiminde toplayacağız. Elde edilen veriler tamamen araştırma amacı ile kullanılacaktır.

Sizden Topladığımız Bilgileri Nasıl Kullanacağız?

Araştırmaya katılımınız tamamen gönüllülük temelinde olmalıdır. Sizden kimlik veya öğrenim gördüğünüz kurum vb. gibi belirleyici hiçbir bilgi istenmemektedir. Cevaplarınız tamamıyla gizli tutulacak, sadece araştırmacılar tarafından değerlendirilecektir. Katılımcılardan elde edilecek bilgiler toplu halde değerlendirilecek ve doktora tez araştırması kapsamında kullanılacaktır. Sağladığımız veriler gönüllü katılım formlarında toplanan kimlik bilgileri ile eşleştirilmeyecektir.

Katılımla ilgili bilmeniz gerekenler:

Çalışma, genel olarak kişisel rahatsızlık verecek sorular içermemektedir. Ancak, katılım sırasında sorulardan ya da herhangi başka bir nedenden ötürü kendinizi rahatsız hissederseniz cevaplama işini yarıda bırakıp çıkmakta serbestsiniz. Böyle bir durumda çalışmayı uygulayan kişiye, çalışmadan çıkmak istediğinizi söylemek yeterli olacaktır.

Araştırmayla ilgili daha fazla bilgi almak isterseniz:

Bu çalışmaya katıldığınız için şimdiden teşekkür ederiz. Çalışma hakkında daha fazla bilgi almak için ODTÜ doktora öğrencisi Yasin AY ile iletişim kurabilirsiniz.

Yukarıdaki bilgileri okudum ve bu çalışmaya tamamen gönüllü olarak katılıyorum.

(Formu doldurup imzaladıktan sonra uygulayıcıya geri veriniz).

Ad - Soyad:

Tarih:

İmza

C. PARENTAL APPROVAL FORM

VELİ ONAY FORMU

Sevgili Anne/Baba,

Bu çalışma Orta Doğu Teknik Üniversitesi doktora öğrencisi Yasin AY tarafından yürütülmektedir.

Bu çalışmanın amacı nedir? Bu çalışmada araştırmacı Akış Kuramı ilkeleri temel alınarak yapılan bir öğretimin, öğrencilerin matematik dersine yönelik motivasyonlarına, akış durumlarına ve başarılarına etkisi olup olmadığını belirlemeyi amaçlamaktadır.

Çocuğunuzun katılımcı olarak ne yapmasını istiyoruz?: Bu amaç doğrultusunda, çocuğunuzdan Matematik Testi, Matematikte Akış Ölçeği ve Matematik Dersi Güdülenme Ölçeği'ni cevaplamasını isteyeceğiz ve cevaplarını yazılı biçimde toplayacağız. Sizden çocuğunuzun katılımcı olmasıyla ilgili izin istediğimiz gibi, çalışmaya başlamadan çocuğunuzdan da sözlü olarak katılımıyla ilgili rızası mutlaka alınacak.

Çocuğunuzdan alınan bilgiler ne amaçla ve nasıl kullanılacak?: Çocuğunuzdan alacağımız cevaplar tamamen gizli tutulacak ve sadece araştırmacı tarafından değerlendirilecektir. Elde edilecek bilgiler sadece bilimsel amaçla doktora tez çalışması kapsamında kullanılacak, çocuğunuzun ya da sizin ismi ve kimlik bilgileriniz, hiçbir şekilde kimseyle paylaşılmayacaktır.

Çocuğunuz ya da siz çalışmayı yarıda kesmek isterseniz ne yapmalısınız?: Katılım sırasında sorulan sorulardan ya da herhangi bir uygulama ile ilgili başka bir nedenden ötürü çocuğunuz kendisini rahatsız hissettiğini belirtirse, ya da kendi belirtmese de araştırmacı çocuğunuzun rahatsız olduğunu öngörürse, çalışmaya sorular

tamamlanmadan ve derhal son verilecektir. Şayet siz çocuğunuzun rahatsız olduğunu hissederseniz, böyle bir durumda çalışmadan sorumlu kişiye çocuğunuzun çalışmadan ayrılmasını istediğinizi söylemeniz yeterli olacaktır.

Bu çalışmayla ilgili daha fazla bilgi almak isterseniz: Çalışmaya katılımınızın sonrasında, bu çalışmayla ilgili sorularınız yazılı biçimde cevaplandırılacaktır. Çalışma hakkında daha fazla bilgi almak için doktora öğrencisi Yasin AY ile iletişim kurabilirsiniz. Bu çalışmaya katılımınız için şimdiden teşekkür ederiz.

Yukarıdaki bilgileri okudum ve çocuğumun bu çalışmada yer almasını onaylıyorum (Lütfen alttaki iki seçenekten birini işaretleyiniz).

Evet onaylıyorum ____

Hayır, onaylamıyorum ____

Anne/Babanın adı-soyadı: _____ Tarih: _____

Çocuğun adı soyadı ve doğum tarihi: _____

İmza: _____

(Formu doldurup imzaladıktan sonra araştırmacıya ulaştırınız).

D. AFTER PARTICIPATION INFORMATION FORM

KATILIM SONRASI BİLGİ FORMU

Bu araştırma, ODTÜ Eğitim Bilimleri Bölümü Eğitim Programları ve Öğretim doktora öğrencisi Yasin AY tarafından yürütülmektedir. Çalışmanın amacı, Akış Kuramı ilkeleri temel alınarak hazırlanan öğretimin, öğrencilerin matematik dersine yönelik motivasyonlarına, akış durumlarına ve başarılarına etkisi olup olmadığını belirlemektir.

Akış kuramı, bireylerin içsel motivasyon sağlayan deneyimlerinin, o aktiviteye katılımlarını artırdığını savunan bir motivasyon kuramıdır. Özellikle eğitim ortamlarında öğrencilerin motivasyonlarının ve derse katılma isteklerinin artırılabilceğini savunan kuram, Csikszentmihalyi (1975) tarafından ortaya atılmış olup, bireylere sunulan öğretimin zorluk düzeyiyle sahip olunan beceri arasında denge kurulması durumunda hedeflenen bu duruma ulaşılabileceğini öngörmektedir.

Bu çalışmadan alınacak ilk verilerin 2017-2018 eğitim öğretim yılında elde edilmesi amaçlanmaktadır. Elde edilen bilgiler sadece bilimsel amaçla kullanılacaktır. Bu araştırmaya katıldığınız için tekrar çok teşekkür ederiz.

Araştırmanın sonuçlarını öğrenmek ya da daha fazla bilgi almak için aşağıdaki araştırmacıya başvurabilirsiniz.

Çalışmaya katkıda bulunan bir gönüllü olarak katılımcı haklarınızla ilgili veya etik ilkelerle ilgili soru veya görüşlerinizi ODTÜ Uygulamalı Etik Araştırma Merkezi'ne iletebilirsiniz.

E. APPROVAL OF MINISTRY OF NATIONAL EDUCATION

T.C.
İZMİR VALİLİĞİ
İl Milli Eğitim Müdürlüğü

ARAŞTIRMA DEĞERLENDİRME FORMU

ARAŞTIRMA SAHİBİNİN	
Adı Soyadı	Yasin AY
Kurumu / Üniversitesi	ODTÜ, Sosyal Bilimler Enstitüsü Eğitim Bilimleri, Eğitim Programları ve Öğretim
Araştırma yapılacak iller	İzmir
Araştırma yapılacak eğitim kurumu ve kademesi	
Araştırmanın konusu	Akış Kuramı İlkelerine Göre Hazırlanmış Öğretimin Öğrencilerin Matematik dersine Yönelik Motivasyon, Akış Durumu ve Başarılarına Etkisi
Üniversite / Kurum onayı	---
Araştırma/proje/ödev/tez önerisi	Akış Kuramı İlkelerine Göre Hazırlanmış Öğretimin Öğrencilerin Matematik dersine Yönelik Motivasyon, Akış Durumu ve Başarılarına Etkisi (Tez)
Veri toplama araçları	Matematik Motivasyon Ölçeği Matematikte Akış Durumu Ölçeği Matematik Başarı testi Gönüllü Katılım Formu Veli Onay Formu Katılım Sonrası Bilgi Formu
Görüş istenilecek Birim/Birimler	----
KOMİSYON GÖRÜŞÜ	
İlgi: Milli Eğitim Bakanlığı'nın 22/08/2017 tarihli ve 3558626-10.06-e.12607291 sayılı Araştırma, yarışma ve Sosyal Etkinlik İzinleri Konulu, 2017/25 Sayılı Genelgesi. Genelge gereğince; araştırmanın 2017-2018 öğretim yılında eğitim öğretimi aksatmayacak ve eğitim kurumları yöneticilerinin uygun gördüğü şekli ile yapılmasına oybirliği ile karar verilmiştir.	
Komisyon Kararı	Oybirliği ile alınmıştır.
Muhalif üyenin Adı ve Soyadı: ----	Gerekçesi; -----

KOMİSYON

26/02/2018

**F. DISTRIBUTION OF TEST ITEMS ACROSS THE OBJECTIVES OF
ELEMENTARY FIFTH GRADE CURRICULUM BEFORE THE PILOT
STUDY**

<i>The units</i>	<i>The topics</i>	<i>Objectives</i>	<i>Item numbers in the pilot test</i>
		Students will be able to;	
Numbers and operations	Percentages	1. M.5.1.6.1. denote fractions with a denominator of 100 with the percent symbol (%).	1, 2
		2. M.5.1.6.2. associate a percentile with a fraction and decimal representation of the same magnitude, converts these representations into each other.	1, 2, 4
		3. M.5.1.6.4. find the amount corresponding to a specified percentage of a multiplicity.	3, 7
Geometry and measurement	Basic Geometric Concepts and Drawings	4. M.5.2.1.1. explain the line, line segment, ray and shows them with symbol.	5, 6
		5. M.5.2.1.2. express the position of a point relative to another point using direction and units.	11, 12
		6. M.5.2.1.3. draw line segments of equal length to a given line segment.	15, 16
		7. M.5.2.1.4. create acute, right, and obtuse angles by referencing a 90° angle; Determine whether a created angle is acute, right, or obtuse.	13, 18
		8. M.5.2.1.5. draw a perpendicular from a point on or off a line.	19, 20
		9. M.5.2.1.6. construct line segments parallel to a given line segment, and interpret whether the drawn segments are parallel or not.	21, 22

Triangles and Rectangles	10.	M.5.2.2.1. name and create polygons; and recognize their basic elements.	8, 17, 23
	11.	M.5.2.2.2. create triangles according to their angles and sides, classify the different triangles formed according to their side and angle properties.	24
	12.	M.5.2.2.3. identify and draw the basic elements of rectangle, parallelogram, rhombus and trapezoid.	14, 26, 28
	13.	M.5.2.2.4. determine the sum of the measures of the interior angles of triangles and quadrilaterals; and find the missing angle.	27, 29, 30
Measuring Length and Time	14.	M.5.2.3.1. recognize the units of length measurement; Convert meter-kilometer, meter-decimeter-centimeter-millimeter units and solves related problems.	25, 31
	15.	M.5.2.3.2. calculate perimeters of triangles and quadrilaterals, create different shapes with a given perimeter.	9, 32, 33
	16.	M.5.2.3.3. recognize time units, convert them to each other and solve related problems.	36, 40
Measuring Area	17.	M.5.2.4.1. calculate the area of the rectangle, using the square centimeters and square meters.	34, 35, 37
	18.	M.5.2.4.3. create different rectangles with a given area.	10, 38

**G. ITEM DIFFICULTY AND ITEM DISCRIMINATION INDICES
DETERMINED IN THE PILOT IMPLEMENTATION OF MATHEMATICS
TEST**

Item No	Discrimination Index (r_{jx})	Difficulty Index (p_j)	Item No	Discrimination Index (r_{jx})	Difficulty Index (p_j)
Item 1*	0,46	0,43	Item 21*	0,63	0,67
Item 2*	0,42	0,67	Item 22	0,39	0,78
Item 3*	0,42	0,36	Item 23	0,52	0,75
Item 4	0,40	0,30	Item 24*	0,67	0,45
Item 5*	0,52	0,66	Item 25	0,10	0,28
Item 6	0,48	0,49	Item 26	0,39	0,61
Item 7	0,36	0,31	Item 27	0,24	0,30
Item 8	0,43	0,80	Item 28*	0,44	0,45
Item 9*	0,64	0,59	Item 29	0,25	0,27
Item 10	0,19	0,24	Item 30*	0,34	0,32
Item 11*	0,30	0,81	Item 31*	0,47	0,33
Item 12	0,34	0,36	Item 32*	0,34	0,42
Item 13*	0,47	0,75	Item 33	0,34	0,28
Item 14	0,41	0,34	Item 34	0,27	0,28
Item 15*	0,48	0,65	Item 35	0,25	0,29
Item 16	0,39	0,73	Item 36	0,24	0,32
Item 17	0,54	0,42	Item 37*	0,45	0,33
Item 18	0,44	0,42	Item 38*	0,44	0,38
Item 19	0,13	0,25	Item 39	0,13	0,31
Item 20*	0,36	0,56	Item 40*	0,33	0,44
Mean Score		18.39			
Standard Deviation		6.66			
Mean Discrimination Index (r_{jx})		0.39			
Mean Difficulty (p_j)		0.46			
KR-20 Reliability		0.83			

(*) = Represents items selected for the final version of the MAT.

**H. DISTRIBUTION OF ITEMS ACCORDING TO THE DIFFICULTY
INDICES IN THE PILOT IMPLEMENTATION**

Item Index (p_j)	Difficulty	Number of Items	Item Number	Category
$p_j > .80$		2	8, 11	Very easy
$.60 < p_j < .79$		9	2, 5, 13, 15, 16, 21, 22, 23, 26	Easy
$.40 < p_j < .59$		10	1, 6, 9, 17, 18, 20, 24, 28, 32, 40	Moderate
$.20 < p_j < .39$		19	3, 4, 7, 10, 12, 14, 19, 25, 27, 29, 30, 31, 33, 34, 35, 36, 37, 38, 39	Difficult
$p_j < .19$		0	-	Very difficult
Total		40		

I. SAMPLE ITEMS FROM FINAL VERSION OF MATHEMATICS TEST

MATEMATİK BAŞARI TESTİ (Örnek Maddeler)

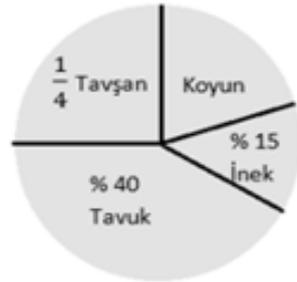
Sevgili öğrenciler;

Aşağıda yer alan testte, sizin matematik dersinde öğrendiğiniz konuları ölçen 18 adet soru bulunmaktadır. Verdiğiniz yanıtlar sadece araştırma kapsamında kullanılacak olup, herhangi bir notlandırma amacı ile kullanılmayacak ve araştırmacı dışında hiç kimse ile paylaşılmayacaktır. Testi cevaplandırmanız için size yaklaşık 40 dk süre verilecektir. Lütfen tüm soruları atlamadan dikkatlice cevaplandırınız.

Araştırmaya verdiğiniz katkı için teşekkür ederiz.

Araştırmacı: Yasin AY

1.

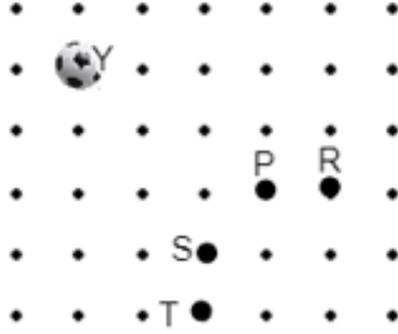


Yandaki grafikte bir çiftlikte yer alan hayvan türlerinin dağılımı verilmiştir.

Grafiğe göre, koyunların sayısı tüm hayvanların yüzde kaçındır?

- A) %15 B) %20
C) %30 D) %45

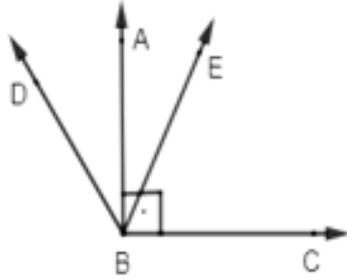
2. Y noktasında bulunan bir top 2 birim aşağıya 4 birim sağa doğru taşınıyor.



Buna göre topun en son geldiği nokta aşağıdakilerden hangisidir?

- A) R B) P C) S D) T

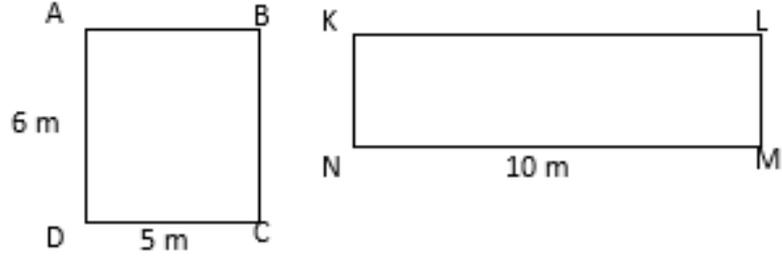
3.



Yukarıda verilen şekle göre aşağıdakilerden hangisi dar açı değildir?

- A) \widehat{DBA} B) \widehat{EBC}
C) \widehat{DBC} D) \widehat{ABE}

4.



Yukarıda verilen ABCD ve KLMN dikdörtgenlerinin alanları eşittir.

Buna göre, KLMN dikdörtgeninin bir kısa kenarı kaç m'dir?

- A) 1 B) 2 C) 3 D) 5

CEVAP ANAHTARI

- | | |
|---|---|
| 1 | B |
| 2 | A |
| 3 | C |
| 4 | C |

J. FLOW STATE SCALE IN MATHEMATICS

MATEMATİK DERSİNDE AKIŞ DURUMU ÖLÇEĞİ

Sevgili Öğrenciler,

Aşağıda matematik dersinde neler hissettiğinize ve düşündüğünüze yönelik ifadeler yer almaktadır. İfadeleri size uygun olup olmadığı açısından değerlendiriniz. İfadeleri boş bırakmamaya özen gösteriniz.

Katkılarınız için teşekkür ederim.

Yasin AY

ODTÜ Doktora Öğrencisi

		Hiç uygun değil	Uygun değil	Uygun	Çok uygun
1	Matematik dersini dinlemek bana zevkli geliyor çünkü anlatılan konuları anlıyorum.				
2	Matematik dersini zevkle dinliyorum, çünkü konuları seviyorum.				
3	Matematik dersindeki konular akıcı geçtiği için dersten sıkılmıyorum.				
4	Matematik dersinde konuları anladığım için zamanın nasıl geçtiğini anlayamıyorum				
5	Matematik dersinde anlatılan konular ilgimi çektiği için dersi dikkatli dinliyorum.				
6	Matematik dersinde hep bildiğim konular anlatıldığı için sıkılıyorum.				
7	Matematik dersi benim kapasitemi zorlamadığı için derste sıkılıyorum.				
8	Matematik öğretmenimiz konuları çok basit anlattığı için derste sıkılıyorum.				
9	Matematik dersinde sorulan sorular çok kolay olduğu için dersten sıkılıyorum.				
10	Matematik dersini anlamadığım için derste bunalıyorum.				
11	Matematik dersinde öğretmenimiz seviyemize uygun anlatmadığı için derste bunalıyorum.				
12	Matematik dersinde konular zor geldiği için derste bunalıyorum.				
13	Matematik dersinde anlatılan konular soyut olduğu için bunalıyorum.				

K. MATHEMATICS MOTIVATION SCALE

MATEMATİK DERSİ GÜDÜLENME ÖLÇEĞİ						
<i>Sevgili Öğrenciler;</i> Bu araştırma, sizlerin matematik dersine yönelik güdülenme (motive olma) durumunuzu belirlemek amacıyla yapılmaktadır. Burada yer alan maddelere, doğru ya da yanlış şeklinde bir değerlendirme yapılmayacaktır. Araştırmadan elde edilen veriler, sadece bilimsel amaçla kullanılacak, şahsınızla (sizinle), okulunuzla veya öğretmenlerinizle ilgili herhangi bir değerlendirme yapılmayacaktır. Bu nedenle ekteki her bölümü soruları atlamadan, dikkatlice doldurmanız gerekmektedir. İsminizi yazmanıza gerek yoktur. Belirtilen ifadelerden size en uygun olanını (X) koyarak işaretleyiniz. Göstermiş olduğunuz ilgi ve vermiş olduğunuz katkı için teşekkür ederim.		Tamamen Katılıyorum	Katılıyorum	Orta Derecede Katılıyorum	Katılmıyorum	Kesinlikle Katılmıyorum
1	Matematik dersinde öğretmenim tarafından takdir edilmek isterim.					
2	Sınıfta matematikle ilgili bir problemi çözmeyi başarmca arkadaşlarımdan takdir görürüm.					
3	Matematik dersinden başarılı olduğum zaman ailem mutlu olur ve beni takdir eder.					
4	Sınıfta, matematik dersinden en yüksek notu ben almak isterim.					
5	Arkadaşlarıma, matematikten anlamadıkları konularda yardımcı olarak onların beğenisini kazanmak isterim.					
6	Benim için matematikten daha önemli dersler var.					
7	Matematiği iyi bilmenin eğitim hayatım dışında da işime yarayacağını düşünüyorum.					
8	Matematik dersinde kullanılan materyaller (araç-gereçler, bilgisayar vb.) matematiğe olan ilgimi artırır.					
9	Matematik dersiyile ilgili tüm bilgilere sahip olmak isterim.					
10	Arkadaşlarımla birlikte matematik çalışmaktan çok keyif alırım.					
11	Matematik dersine çalışmaktan hoşlanmıyorum.					
12	Öğretmenin matematik dersinde yaptığı etkinlikler (oyunlar, yarışmalar, bilgisayar destekli sunumlar vb.) matematiğe olan ilgimi artırır.					
13	Matematik konularını yeterince anlamıyorsam, bu durum benim gerekli çabayı göstermediğimden kaynaklanmaktadır.					
14	Eğer yeterince çalışırsam, matematiğin kolay olacağına inanıyorum.					
15	Matematik konularını anlamakta zorlandığım zaman, birilerinden yardım alabileceğimi düşünüyorum.					
16	Matematik sınavlarında başarısız olmaktan çok kaygılanırım.					
17	Matematik dersinde çok başarılı olacağıma inanmıyorum.					
18	Matematik dersinden başarısız olmaktan korkmuyorum.					
19	Matematik dersinden notumu yükseltmek için çok çalışırım.					

20	Matematik konularını iyi öğrenmezsem, eğitim hayatımda yeterince başarılı olacağımı düşünmüyorum.					
21	Matematikte başarılı olmak için pek çok fedakarlık (daha az oyun oynarım, daha az televizyon izlerim ve arkadaşlarımla ve bilgisayarda daha az vakit geçiririm) yapabilirim.					
22	Matematik dersinde daha başarılı olmama yardımcı olacak, proje ve performans görevleri almak isterim.					
23	Matematik dersinde başarısız olursam kendimi kötü hissederim.					
24	Matematikten başarılı olabileceğimi herkese kanıtlamak isterim.					
25	Matematikte başarılı olmak benim için çok önemlidir.					
26	Matematikte, başarılı olmam için dersi çok dikkatli dinlemem gerektiğini düşünüyorum.					
27	Matematikten başarılı olursam, ilerde istediğim mesleğe sahip olacağıma inanıyorum.					
28	Ailemin beklentilerini karşılamak için matematikten başarılı olmak istiyorum.					
29	Matematikte başarılı olduğum zaman ödül alacaksam daha çok çalışırım.					
30	Öğretmenimi ve beni seven insanları gururlandırmak için matematikten çok başarılı olmak istiyorum.					
31	Matematiği ve diğer dersleri iyi öğrenip sınavları kazanarak çok iyi okullarda okumak istiyorum.					
32	Matematik dersinde sorulan soruları (soru çözme yarışmasında vb.) herkesten önce çözmek istiyorum.					

L. INTERVIEW SCHEDULE

GÖRÜŞME FORMU

Tarih: ___/___/20__

Saat (Başlangıç/Bitiş) _____ / _____

Merhaba, benim adım Yasin AY. ODTÜ’de doktora yapmaktayım. “Öğrencilerin Matematik Motivasyonu, Akış Durumları ve Matematik Başarıları” üzerine bir araştırma yapıyorum. Sizinle 11 hafta boyunca yürütmüş olduğumuz matematik dersi ve yaptığımız etkinlikler hakkında bir görüşme yapmak istiyorum. Bu görüşmede amacım, matematik dersleri hakkında siz öğrencilerin ne düşündüğünü belirlemek, derslerin daha etkili yapılabilmesi için öğrencilerin görüşlerini öğrenebilmektir.

Araştırmada hiçbir şekilde isminiz geçmeyecek ve görüşme esnasında aşağıdaki sorulara verdiğiniz tüm cevaplar gizli tutulacaktır. Görüşmedeki cevaplarınızı unutmamak ve farklı öğrencilerin cevaplarını karşılaştırabilmek için izniniz doğrultusunda görüşme kaydedilecektir.

İzin verirseniz sorulara başlamak istiyorum.

SORULAR

1. Matematik derslerinde kendini nasıl hissediyordun?
 - a. Hangi durumlarda sıkılmış hissettin?
 - b. Hangi durumlarda kaygı/stres yaşadın?
2. Matematik dersleri senin için ne kadar keyifli geçiyordu?
 - a. Hangi durumlar senin için en eğlenceliydi?

- b. Hangi durumlar senin için en az eğlenceliydi?
 - c. “Keşke şu an başka bir şey yapıyor olsaydım” dediğin zamanlar oluyor muydu? (Örnek verebilir misin?)
3. Matematik dersinde seni motive eden/istekli hale getiren şeyler nelerdi?
 - a. Matematik dersinde yapılan etkinlikler senin matematik öğrenme isteğini nasıl etkiledi?
 - b. Sence matematik dersi için harcadığın çaba bu etkinlikler sayesinde arttı mı azaldı mı?
4. Matematik dersinde yapılan etkinliklerin zorluğu konusunda neler söyleyebilirsin?
 - a. Orta düzeyde miydi? Zor muydu/Kolay mıydı?
5. Derste yapılan etkinliklerden, o gün ne öğrenileceğini nasıl anlıyordun?
6. Matematik dersinde öğretmeninden ve sınıf/grup arkadaşlarından nasıl yardım/öneri/düzeltilme/görüşler istiyordun?
 - a. İstediklerin anda alabiliyor muydun?
 - b. Ne sıklıkta alabiliyordun?
 - c. Peki bunlar öğrenmeni nasıl etkiledi?
7. Matematik derslerinde genel olarak zaman nasıl geçiyordu?
 - a. Bir an önce dersin bitmesini/zilin çalmasını mı yoksa etkinliğe/derse devam etmek mi istiyordun? Neden?
8. Matematik dersleri ne kadar ilginizi çekiyordu?
 - a. Derste yapılan etkinliklerden hoşlanıyor muydun?
 - b. Bütün matematik derslerinde benzer etkinlikler yapmak ister misin?
9. Derste yapılan etkinliklere ne kadar odaklanabiliyordun? (Konsantre olabiliyordun?)
10. Matematik dersinde yapılan etkinlikler sırasında, kendini kaptırıp oluyor muydu?
 - a. Çok eğlendiğin, zamanın nasıl geçtiğini anlamadığın anlar oldu mu?
 - b. Bunu neye bağlıyorsun?
11. Matematik dersinde kendini ne kadar özgür hissediyordun?
 - a. Örnek verebilir misin?

M. OBSERVATION FRAME

Gözlem Formu

Konu:

Tarih:

Kazanımlar:

	Gözlenen Akış Boyutları	• Notlar
1	Öğrencinin becerileri ile etkinlik düzeyi arası denge (Challenge-skill balance: sadece sonuç değil, sürecin önemsenmesi, verilen cevapların arkasında yatan sebeplerin istenmesi, derinlemesine anlamının desteklenmesi => challenge)	
2	Öğrencilerin konuya/etkinliğe odaklanmış dikkat/yoğun konsantrasyon/yoğunlaşabilme (etkinliğin spontane ilerlemesi, otomatikleşmesi)	•
3	Öğrencilerin aktivite üzerindeki kontrolü/özgürlük(Autonomy) (Düşüncelerini rahatça ifade etme, Hata yapmaktan korkmama/hatayı öğrenmek için avantaja çevirme, grup içi özgürce kararlar alma, kendi sınırlarını zorlama çabası)	•

4	Etkinliğin ilgi çekici olması (Konuya önem verme, gerçek yaşam problemleri, otantiklik, öğrenciye anlamlı gelme vs.)	•
5	Etkinliğin hedefinin açık/anlaşılır olması	•
6	Anında dönüt/destek sağlanması (Açıklama, aydınlatma, yardımlaşma, olumlu dönüt sağlama)	•
7	Etkinliğin yapılmasından Keyif alma hissi (Etkinlik/dersten keyif alma, autotelic= kişinin etkinliği etkinliğin kendisi için yapması, etkinliğin keyif verdiği için yapılması, etkinliği yapmanın içsel ödül taşıması hissi, Pozitif duyuşsal destek sağlama, hassasiyet ve nazik yaklaşım, mizah vs.)	•
8	Öz bilincin kaybolması hissi (kendini etkinliğe kaptırma, etkinlik dışındaki kaygı ve engelleri bilincinden uzaklaştıracak kadar derin olma hissi)	•
9	Zamanın normalden hızlı/yavaş geçmesi hissi	•
	Diğer notlar:	•

N. SAMPLE LESSON PLAN AND ACTIVITIES

Akış Kuramı İlkelerine Dayalı Gerçekçi Matematik Eğitimi ile Zenginleştirilmiş Matematik Öğretiminde Kullanılan Ders Planı Şablonu

Ders:

Öğrenme Alanı:

Alt Öğrenme Alanı:

Sınıf düzeyi:

Süre:

Stratejiler:

A) Kazanımlar:

B) Öğretim Materyalleri:

C) Öğrenme-Öğretme Süreci:

1. Giriş

a. Dikkati çekme / Isındırma

b. Güdüleme

b. Problem durumunun sunulması / Hedeflerin açıklanması /
paylaşılması

c. Grupların oluşturulması

2. Etkinlik

a. Grupların problem üzerinde çalışması

b. Grupların çözüm önerilerini paylaşması

c. Grup tartışması

3. Sonuç (Dikey matematikleştirme / Formülleştirme)

4. Değerlendirme

Ders Planı

Ders: Matematik

Öğrenme Alanı: Sayılar ve İşlemler

Alt Öğrenme Alanı: Yüzdeler

Sınıf düzeyi: Ortaokul 5. sınıf

Süre: 2 ders saati (80 dk.)

Strateji-Yöntem: İşbirlikli öğrenme, Problem çözme, Tartışma

A) Kazanımlar:

1. Paydası 100 olan kesirleri yüzde sembolü (%) ile gösterir.
2. Bir yüzdellik ifadeyi aynı büyüklüğü temsil eden kesir ve ondalık gösterimle ilişkilendirir, bu gösterimleri birbirine dönüştürür.

B) Öğretim Materyalleri, Araç-Gereçler: Gerçek hayattan konu ile ilgili nesnelerin resimleri, Akıllı tahta, Renkli boyama kalemleri, Etkinlik kâğıtları, Boya kutusu ve fırçası

C) Öğrenme-Öğretme Süreci:

1. Giriş

a. Isındırma / Dikkati çekme / Ön öğrenmelerle bağlantı kurma

- Öğretmen, sınıfa bir boya kutusu ve bir boya fırçası ile girer.
- Öğrencilerin dikkatini çeken bu nesnelerin ne olduğunu, ne işe yaradıklarını, daha önce bir evin duvarlarının boyanırken görüp görmediklerini vb. sorular sorar.
- Daha sonra öğrencilerin odalarının duvarlarının ne renklerde olduğunu sorarak aynı renkte olanlarının sayısını tahtaya not eder.
- Öğrencilerden kaçının odasında, hangi renkten kaç adet olduğunu sorarak konuya giriş yapılır.
- Belirli renklerin sayılarını ifade ederken daha önce öğrendikleri kesirler ve ondalık gösterimlerle ifade etmelerini ister (3/20 si beyaz, 4/20 si pembe vb. gibi).
(*Intertwining*)

b. Gdleme

- Daha sonra ğrencilere bu kesir ve ondalık gsterimlerin farklı Őekilde ifade edilip edilemeyeceđi, ya da nasıl ifade edilebileceđi sorularak onların merak duygusunun artması sađlanır.
- ğrenciler belli bir sre fikirlerini belirttikten sonra, akıllı tahta yardımıyla EK-3'te yer alan resimler gsterilir.
- Resimlerin zerinde yer alan sayıların ne anlam ifade edebileceđi ile ilgili ğrencilerin dŐnceleri alınır.
- ğrencilerin gnlk hayatta;
 - Bir spor etkinliđini izlerken tribnlerin ne kadarının dolu olduđunu,
 - Bilgisayar oyunu oynarken oyundaki karakterin ne kadar gcnn kaldıđını,
 - Telefon/tablet/bilgisayarları Őarj etmek iin pilin ne kadar dolu olduđunu... vb. nasıl ifade ettikleri tartıŐılarak konuya geiŐ yapılır.
- Bu resimlerden yola ıkılarak, televizyonlarda, alıŐveriŐ merkezlerinde, reklam panolarında sıklıkla karŐılaŐtıkları % ifadesinin ne olduđu hakkında tahminlerde bulunmaları istenir.
- ğretmen "Sizce neden kesir ve ondalık gsterimleri yzde olarak ifade etmeye ihtiya duyulmuŐtur?", "% sembol neden kullanılır?" Őeklinde sorular sorarak ğrencilerin ilgisini eker.

c. Problem durumunun sunulması / Hedeflerin aıklanması / paylaŐılması

- ğretmen, "bugnk derste kesir ve ondalık gsterimlerin, yzdelik ifadelerle nasıl gsterileceđini, bunların birbirine nasıl dnŐtrleceđini ve yzde (%) sembolnn nasıl kullanılacađını ğreneceđiz" diyerek dersin hedeflerini aıklar.

d. Grupların oluŐturulması

- ğrencilerden 5-6 kiŐilik gruplar oluŐturmaları istenir.
- ğrencilere daha iyi, verimli ve etkili alıŐabileceklerini dŐndkleri arkadaŐlarıyla alıŐmalarına izin verilmelidir. (Ancak burada grup dinamikleri ve cinsiyet, akademik baŐarı vb. faktrler bakımından heterojen dađılımın sađlanmasına dikkat edilmelidir.)

2. Etkinlik

a. Grupların problem üzerinde çalışması / Keşfetme

- Öğrencilere EK-1'deki etkinlik kağıtları dağıtılır ve incelemeleri istenir.
- Etkinliğin amacı, öğrencilerden neler istendiği gibi konularda grupların kendi içinde fikir alışverişi yapmaları istenir.
- Grupların gerekli iş bölümü, görev dağılımı gibi konularda organize olmaları konusunda hatırlatma yapılır. (Bu işlemleri öğrencilerin kendileri belirlemeleri, öğrencilere kontrol ve özerklik hissi sağlaması açısından önemlidir).
- Gruplara etkinlikte yer alan görevleri yerine getirmeleri için yeterli zaman verilir.
- Etkinlik esnasında öğrenciler kendilerine verilen gerçek hayat problemlerini, kendi dil ve sembolleri ile tanımlamaya çalışırlar (*Horizontal mathematization*).
- Öğrenciler etkinlikte yer alan problem durumuna, sahip oldukları informal bilgiler ile çözüm üretmeye çalışarak, RME'nin önermiş olduğu şekilde, “Uygulama, kavrama ve bilgi” basamaklarından geçerek formal bilgiye ulaşmaları sağlanır.
- Bu süreçte öğrenciler kendileri grup içinde tartışıp karar vererek, probleme kendi çözüm önerilerini getirecek, istedikleri sayıda renkleri belirleyecek ve farklı renkteki karoların sayısını bütünün parçası olarak hangi kesir ve ondalık gösterime karşılık geldiğini ifade edeceklerdir.
- Öğrenciler çözümlerinin doğruluğunu gerekli yönlendirmeler sayesinde grup içinde tartışarak kendileri yapacaklardır.
- Öğretmen, grup çalışması esnasında öğrencilere ihtiyaç duydukları anda ipuçları vererek onlara rehberlik eder, kavramları öğrenmelerine yardımcı olur (*Guided reinvention*).
- Öğretmen öğrencilere grup arkadaşlarına her fırsatta yardımcı olmaları konusunda hatırlatmalarda bulunmalıdır. Kendisi de ihtiyaç duyulduğu anda öğrencilere açık, destekleyici ve bilgilendirici geri bildirimler sağlamalıdır.
- Öğretmen kendisine sorulan soruları sınıftaki diğer öğrencilere “arkadaşınızın şöyle bir sorusu var, ... bu konu hakkında siz ne düşünüyorsunuz?” şeklinde yönlendirmeler yaparak, sınıftaki tüm öğrencilerin konu hakkında derinlemesine düşünmelerini sağlayabilir.
- Öğretmen sürekli olarak gruplar arasında gözlem yapmalı, hızlı ilerleyen gruplara “neden böyle düşündüğünüzü açıklar mısınız? Peki şöyle olsaydı yanıtınız değişir

miydi? Nasıl/Neden?” gibi sorular sorarak; ilerlemekte zorlanan gruplara ise bilgilendirici geribildirimler vererek veya problemleri daha basit parçalara bölerek zorluk düzeyini dengede tutmalıdır.

b. Grupların çözüm önerilerini paylaşması (Reflection)

- Öğretmen her grubun oluşturduğu tasarımları tüm sınıfla akıllı tahta yardımıyla paylaşmalarını ister.
- Bu tasarımlarda kullanılan karoların sayılarını, kesir ve ondalık gösterimlerle ifade etmelerini ister.

c. Grup tartışması (Discussion)

- Grupların cevaplarını ve problemlerin çözümlerini paylaştıktan sonra, öğretmen tarafından gruplar arasında fikir alışverişinin yoğun bir şekilde yapıldığı tartışma ortamı başlatılır.
- Öğrencilerin birbirlerine geri bildirim vermeleri için “Siz olsaydınız arkadaşlarınızın tasarımına/çözümüne neyi eklerdiniz? Neyi düzeltmek isterdiniz? En beğendiğiniz nokta ne oldu?” şeklinde sorular yöneltilerek tartışma ortamı desteklenir.
- Tartışma esnasında öğrencilerin birbirlerine eleştirel, küçük düşürücü, alaycı tutumlar sergilememesi konusunda dikkatli olunmalıdır.
- Sınıfta sessiz, söz almaktan çekinen, hata yapmaktan korktuğu için tartışma ortamına katılmayan öğrencileri tartışmaya dahil etmek için öğretmen sık sık “hata yapmanın öğrenme için birer fırsat olduğunu, hata yapmaktan asla korkmamaları gerektiğini” hatırlatmalı, sınıfta olumlu duyguları desteklemelidir.
- Öğrencilerin tartışmaları esnasında, öğretmen doğru terminolojinin kullanılıp kullanılmadığını takip eder, gerekli düzeltmeleri hemen yapar.

3. Sonuç (Dikey matematikleştirme / Formülleştirme)

- Bu aşamada dikey matematikleştirmeye odaklanılır. Elde edilen bilgiler matematiksel olarak ifade edilerek kuramsal seviyeye ulaşılır.
- Grupların tasarımlarında kullanılan karo sayılarını kesir ve ondalık gösterimlerle ifade ettikten sonra, bu aşamada öğretmen tarafından gerekli

yönlendirmeler yapılarak paydası yüz olan kesirlerin yüzde sembolü ile nasıl gösterileceği buldurulur.

- Burada öğrencilere dersin başında gösterilen günlük hayattan örnek resimlerden/durumlardan yararlanır.
- Ardından öğrenciler, daha önce kesir ve ondalık gösterimlerle ifade edilen sayıların yüzdelerle ifadeye nasıl dönüştürüleceğini keşfederler.
- Dikey matematikleştirme ile öğrenciler herhangi bir model kullanmadan, verilen kesir ve ondalık gösterimleri yüzdelerle ifade olarak gösterir, bu gösterimleri birbirine dönüştürür.

4. Değerlendirme

- Etkinlikte verilen problem durumuna benzer bir problem durumunun yer aldığı EK-2'deki çalışma kâğıdı gruplara dağıtılarak üzerinde düşünceleri ve çözümler bulmaları istenir.
- Grupların çözümlerini sınıf tartışması yoluyla paylaşmaları sağlanır.
- Öğretmen öğrencilerin verdikleri yanıtları not verme ve değerlendirme amacını taşımamalı, ya da öğrenciyi dizginleme amacıyla kullanmamalıdır.
- Öğrencilere “nasıl” ve “neden” soruları sorularak konuyu anlayıp anlamadıkları gözlemlenir.
- Öğrencilerden derste neler öğrendikleri, dersin nasıl geçtiği, dersle ilgili ne hissettiklerini anlatmaları istenir.
- Öğrencilerden sınıfta yapılan etkinliklere ek olarak kesir, ondalık ifade ve yüzde gösterimlerini içeren problemler oluşturmaları istenir (Ev ödevi).
- Günlük hayatta yüzde sembolü ve yüzdelerle gösterimin kullanıldığı örnekleri gözlemlenmeleri ve bunları bir sonraki derste sınıfta paylaşmaları istenir.
- Bir sonraki derste öğrenecekleri konu ile ilgili kısaca bilgilendirme yapılarak ders sonlandırılır.

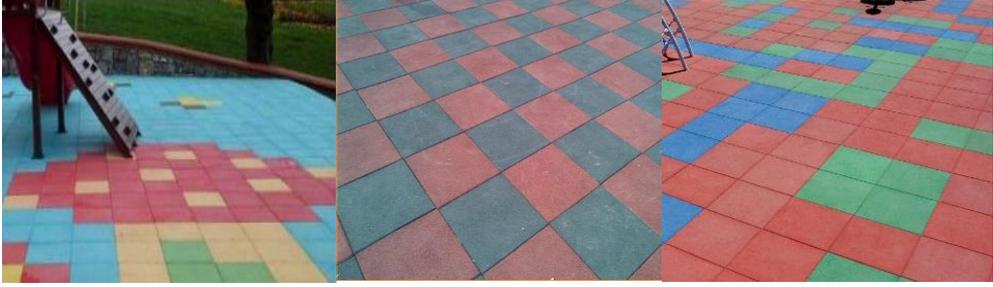
EK-1

OKUL BAHÇESİ TASARIM YARIŞMASI ETKİNLİĞİ

Grup Adı:

Grup Üyeleri:

Benim Bahçem

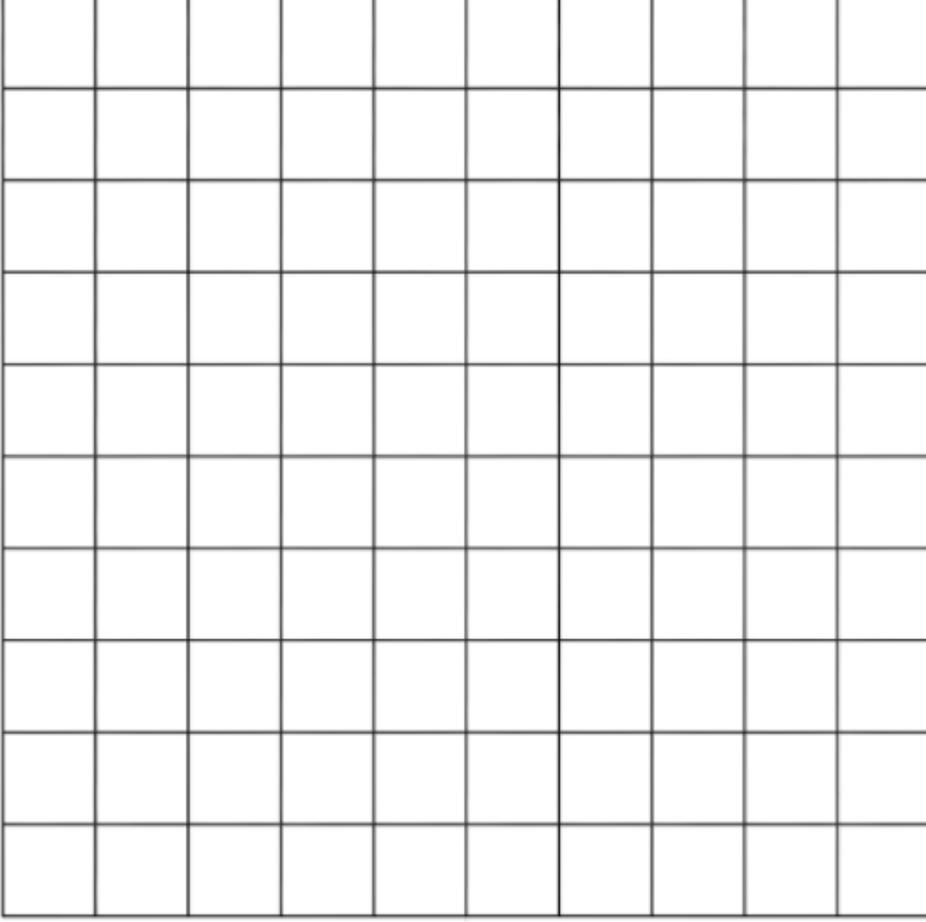


Bir okul bahçesinde oyun oynarken çocukların bazıları beton zeminde yere düşmekte, bunun sonucunda da çeşitli yaralanmalar yaşanmaktadır. Bu duruma bir çözüm bulmak amacıyla toplanan veliler, okulun bahçesine yaralanmaları önleyici kauçuk karolar döşenmesine karar vermişlerdir.

Ancak okul idaresi ve öğretmenlerle yapılan görüşmeler sonucu hangi renkte karoların kullanılacağına ve bu karoların nasıl düzenleneceğine bir türlü karar verememişlerdir. Bunun üzerine okul yönetimi, öğrenciler arasında bir yarışma düzenlemeye karar vermiştir. Yarışmada en çok beğenilen bahçe tasarımı, okul bahçesine uygulanacaktır.

Siz de grubunuzla birlikte aşağıda verilen örnek bahçeyi tasarlayın, tasarımınız okul bahçesine uygulansın!

Okul Bahçesi Tasarımı



1. Yaptığınız tasarımla ilgili aşağıda istenen bilgileri yazınız.

a. Tasarımda kullandığınız karoların renklerini yazınız:

1. renk:

2. renk:

3. renk:

4. renk:

(Başka renk kullandıysanız belirtebilirsiniz.)

b. Kullandığınız karoların hangi renkten kaç adet olduğunu yazınız:

..... renkli karodan adet

..... renkli karodan adet

..... renkli karodan adet

..... renkli karodan adet

(Başka renk kullandıysanız ekleyiniz.)

c. Kullandığınız karoların sayısını kesir gösterimiyle ifade ediniz.

..... renkli karoların kesir gösterimi:

..... renkli karoların kesir gösterimi:

..... renkli karoların kesir gösterimi:

..... renkli karoların kesir gösterimi:

(Başka renk kullandıysanız ekleyiniz.)

- d. Kullandığınız karoların sayısını ondalık gösterimle ifade ediniz.
..... renkli karoların ondalık gösterimi:
..... renkli karoların ondalık gösterimi:
..... renkli karoların ondalık gösterimi:
..... renkli karoların ondalık gösterimi:

(Başka renk kullandıysanız ekleyiniz.)

2. Kullandığınız karoların sayısını Yüzelik (%) gösterimle ifade ediniz.

- renkli karoların yüzde gösterimi:
..... renkli karoların yüzde gösterimi:
..... renkli karoların yüzde gösterimi:
..... renkli karoların yüzde gösterimi:

(Başka renk kullandıysanız ekleyiniz.)

3. Tasarımınızda kullandığınız karoların sayıları ile ilgili aşağıdaki tabloyu doldurunuz. Bu gösterimler arasındaki ilişkiyi tartışınız.

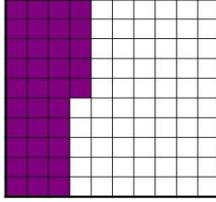
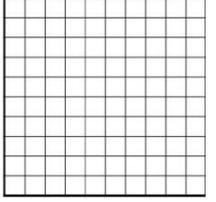
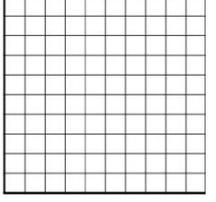
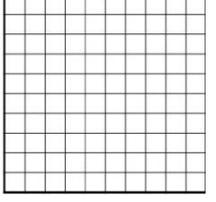
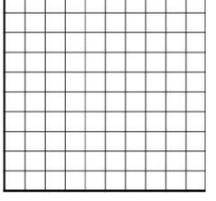
Kullanılan renkler	Sayı	Kesir	Ondalık gösterim	Yüzde ifade
1. Renk:.....				
2. Renk:.....				
3. Renk:.....				
4. Renk:.....				

(Başka renk kullandıysanız ekleyiniz.)

EK-2

5. Sınıf Kurs Listesi

Aşağıda 5. sınıf öğrencilerinin katıldıkları kurslara ait bilgiler yer almaktadır. Ancak tablo doldurulurken bazı yerler unutulmuştur. Boş kalan kutucuklara kesir, ondalık gösterim ve yüzde ifadelerinden uygun olan karşılıklarını yazınız, şeklin uygun alanını boyayınız.

Öğrencilerin gittiği kurslar	Kesir	Ondalık gösterim	Yüzde	Şekil
Matematik				
Fen Bilgisi		0.55		
İngilizce			%80	
Türkçe		0.30		
Sosyal Bilgiler	$\frac{1}{10}$			

EK-3

Yüzde İfadelerinin Kullanımına İlişkin Gerçek Yaşamdan Örnekler



O. CURRICULUM VITAE

PERSONAL INFORMATION

Surname, Name: AY, Yasin

Nationality: Turkish (TC)

Date of Birth: -

Marital Status: -

EDUCATION

Degree	Institution	Year of Graduation
PhD	METU, Curriculum and Instruction, Ankara	2022
MS	Ege University, Curriculum and Instruction, İzmir	2014
BS	METU, Elementary Mathematics Education, Ankara	2011

WORK EXPERIENCE

Year	Place	Enrollment
2011- Present	Ege University	Research Assistant

FOREIGN LANGUAGES

Advanced English

P. TURKISH SUMMARY / TÜRKE ÖZET

AKIŞ KURAMI İLKELERİNE DAYALI GERÇEKÇİ MATEMATİK EĞİTİMİ İLE ZENGİNLEŞTİRİLMİŞ MATEMATİK ÖĞRETİMİNİN ÖĞRENCİLERİN BAŞARI, KALICILIK, MOTİVASYON VE AKIŞ DURUMUNA ETKİSİ

GİRİŞ

Matematik, farklı öğretim kademelerindeki öğrencilerin en başarısız oldukları (Üredi ve Üredi, 2005) ve olumlu duyuşsal özelliklerin daha düşük düzeylerde gözleendiği derslerden biridir (TEDMEM, 2021; Turner & Meyer, 2009). Yapılan çalışmaların pek çoğu bu durumu bilişsel faktörlere bağlamakta, matematik dersinin öğretimi ile ilgili çözüm önerileri sunmaktadır. Ancak bu durum, düşük akademik performansın altında yatan zorlukların bilişsel olmaktan daha çok duyuşsal faktörlerden kaynaklı olabileceğini savunan araştırmacılar tarafından eleştirilmektedir (Csikszentmihalyi ve Mei-ha Wong, 1991). Diğer bir ifadeyle, öğretimde yaşanan kayıplar ve düşük akademik başarının temelinde motivasyonla ilgili sorunların olduğu ileri sürülmekte (Csikszentmihalyi, 1990b), ancak motivasyon, öğretim tasarımı çalışmalarında yeterince yer bulamamakta ve ihmal edilmektedir (Chan & Ahern, 1999). Csikszentmihalyi (1975a) tarafından ortaya atılan Akış Kuramı, bireylerin herhangi bir etkinlikte içsel motivasyonlarını sağlayarak, severek, isteyerek ve keyif alarak etkinliğe katılmalarının sağlanabileceğini savunmaktadır.

Akış Kuramı, öğretim tasarımının gereklilikleri ile motivasyonel tasarım teorisi arasındaki bağlantıyı kuracak özelliklere sahiptir. Örneğin, öğretim tasarımlarında davranışsal ve bilişsel psikolojiden daha fazla yararlanılmasına karşın, Akış Kuramı hümanist psikolojinin unsurlarını da dahil ederek öğretim tasarımındaki motivasyon boyutunun genişletebileceği ileri sürülmektedir (Chan ve Ahern, 1999). Ancak, Akış

Kuramının öğretim tasarımında nasıl uygulanacağına ilişkin yeterli deneysel çalışma bulunmamaktadır. Bu noktada, spesifik bir matematik eğitimi yaklaşımı olarak ortaya atılan ve öğrenenlerin ilgisini çekecek günlük yaşam problemlerinden oluşan öğrenme etkinlikleriyle kendi modellerini oluşturarak anlamlı öğrenmenin gerçekleşmesini sağladığı savunulan (Heuvel-Panhuizen, 2003; Treffers, 1991) GME yaklaşımının öğretimsel tasarım ilkeleri ile Akış Kuramı ilkeleri birbirini desteklemektedir (Heuvel-Panhuizen, 2000; Jackson & Csikszentmihalyi, 1999; Jackson & Ecklund, 2004; Schweinle, Meyer, & Turner, 2006; Üzel, 2007; Heuvel-Panhuizen & Wijers, 2005). Bu nedenle, Akış Kuramıyla GME'nin öğretim tasarımı ilkelerinin entegre edilmesiyle geliştirilen bir öğretimin, öğrencilere eğlenceli, katılımı ve güdülenmeyi sağlayan öğrenme ortamlarının sağlanmasında etkili olabileceği düşünülmektedir.

Özellikle matematik öğretiminin tasarımında daha öğrenilecek çok şey olduğunu belirten Norman'ın (1993) sorduğu şu sorunun dikkate değer olduğu düşünülmektedir: Öğrenirken bu akış durumuna ulaşmanın bir yolu var mıdır?. Bu nedenle, matematik öğrenme ve öğretmede Akış Kuramının nasıl kullanılacağını araştırmak, daha yakından incelemeyi gerektirir. Bu bilgiler ışığında matematik öğretiminde öğrencilerin motivasyonunu ve akademik başarısını artıracak öğretim tasarımı ve uygulamasına ihtiyaç olduğu düşünülmektedir. Bu çalışmada Akış Kuramı ilkelerini ve GME yaklaşımını temele alarak tasarlanan öğretimin, öğrencilerin matematik dersinde başarı, kalıcılık, motivasyon ve akış durumlarına etkisini incelenmiştir. mek amaçlanmıştır.

Çalışmanın Amacı

Bu çalışmanın amacı, Akış Kuramı ilkelerine ve Gerçekçi Matematik Eğitimi'ne dayalı olarak hazırlanan matematik öğretiminin öğrencilerin matematik dersindeki başarı, kalıcılık, akış durumu ve motivasyonları üzerindeki etkilerini incelemektir.

Çalışmanın Önemi

Bu çalışmanın alanyazına birçok açıdan katkı sağlayacağı düşünülmektedir. Özellikle ülkemizde, öğrencilerin matematiğe yönelik olumsuz duygularını, düşük başarı ve özgüvenlerini, matematik umutsuzluklarını ortaya koyan pek çok çalışma yer

almaktadır (Ev, 2003; Gündüz Çetin ve Saracalođlu, 2021; TEDMEM, 2021). Matematik, herkes tarafından kabul edilen bir öneme sahip olmasına rağmen, öğrenciler tarafından sevilmemesi, korku duyulması, ilgi görmemesi ve başarısız olunması, üzerinde önemle durulması gereken bir konudur.

Alanyazında motivasyon ve öğrenci özelliklerinin akademik başarı üzerinde etkisi olduğunu inceleyen pek çok araştırma yer almaktadır. Özellikle içsel motivasyon düzeyi yüksek olan öğrencilerin bu dersten keyif alma ve derse ilgi gösterme düzeylerine paralel olarak daha yüksek matematik başarısına sahip olduğu ifade edilmektedir (Akben-Selçuk, 2017). İçsel motivasyonun ve dolayısıyla matematik başarısının artırılması amacıyla, eğitimcilerin etkili öğretim ortamları tasarlaması, katılımı artıran öğrenme görevleri ve etkinlikler planlamaları önem arz etmektedir. Bu bağlamda, Akış Kuramı ve GME'ye dayalı olarak tasarlanan öğretimin, öğrencilere katıldıkları etkinliklerden keyif almalarını, bu etkinliklerde büyük bir çaba göstermelerini, ve içsel motivasyonlarını artırmalarını sağlayarak, bu ihtiyacı gidermede etkili olacağı ve eğitimcilere yol göstereceği düşünülmektedir (Challco, Andrade, Borges, Bittencourt ve Isotani, 2016; Csikszentmihalyi ve Nakamura, 2014).

Bu çalışmanın odak noktası olarak Akış Kuramının kullanılmış olmasının üç temel nedeni vardır. İlk olarak, akış deneyimi, açıkça belirtilen hedefler, algılanan beceriler ve zorluk dengesi, anında geri bildirim, özerklik ve konsantrasyon gibi kaliteli bir öğrenme ortamı için önemli olan unsurları önermektedir. Ardından, Akış Kuramı öğrenmenin bireylerin öğrenmesini etkileyebilecek olan can sıkıntısı, kaygı, ilgisizlik ve keyif alma gibi duyuşsal yönlerini ele almamıza yardımcı olur. Üçüncüsü, akış deneyimleri, bireylerin etkinliklere yönelik içsel güdülenmelerini sağlayarak daha fazla katılım sağlar. Yani, bir kişi bir etkinliği yapmaktan hoşlanıyorsa, büyük olasılıkla geri dönüp tekrar o etkinliği yapmak isteyecektir.

Akış kuramının pek çok alanda etkisi incelenmiş olsa da eğitimle ilgili yeterince bilgi ve deneyim elde edilmemiştir. Akış Kuramının eğitimle ilgili kullanıldığı çalışmalarda, genellikle okul etkinliklerinde ne kadar akış durumunun gözlemlendiği, ya da öğrencilerin gün içinde hangi eğitim faaliyetlerinde daha fazla akış durumu yaşadığına yönelik incelemelerde bulunduğu görülmektedir (Ak-Şentürk, 2010;

Alperer, 2005; Baydaş, Karakuş, Topu, Yılmaz, Öztürk, & Göktaş, 2015; Inal & Çağiltay, 2007; Kirchhoff, 2013; Sillaots, 2014). Kuramın, bir öğretimin tasarlanması ve uygulanması ile ilgili çok nadir çalışmaya rastlanmış, matematik dersine yönelik öğretim tasarımında bu kuramın kullanıldığı ve deneysel olarak incelendiği neredeyse hiçbir çalışmaya rastlanmamıştır (Aydın, 2005; Hamari et al., 2016; Mannell & Bradley, 1986). Dolayısıyla bu çalışmanın, alanyazında yer alan boşluğu gidermede katkı sağladığı gibi, öğretmenlere, program geliştirme uzmanlarına ve diğer paydaşlara da yararlı sonuçlar sunduğu düşünülmektedir.

Yöntem

Araştırma Deseni

Araştırmada yarı-deneysel araştırma desenlerinden biri olan öntest-sontest kontrol gruplu desen kullanılmıştır. Çalışma, önceden oluşturulmuş olan gruplarla yürütülmüş, grupların denkliği nicel veri toplama araçlarının öntest olarak uygulanmasının ardından belirlenmiştir. Gruplar, birbirine denk oldukları belirlendikten sonra, rastgele bir şekilde deney ve kontrol grubu olarak atanmıştır.

Araştırma Soruları

1. Deney ve kontrol gruplarının Matematik Başarı ve Kalıcılık puanları arasında anlamlı bir fark var mıdır?
2. Deney ve kontrol gruplarının Akış Durumu puanları arasında anlamlı bir fark var mıdır?
 - a. Deney ve kontrol gruplarının Akış alt boyutu puanları arasında anlamlı bir fark var mıdır?
 - b. Deney ve kontrol gruplarının Sıkılma alt boyutu puanları arasında anlamlı bir fark var mıdır?
 - c. Deney ve kontrol gruplarının Kaygı alt boyutu puanları arasında anlamlı bir fark var mıdır?

3. Deney ve kontrol gruplarının Matematik Motivasyonu puanları arasında anlamlı bir fark var mıdır?

4. Deney grubu öğrencilerinin uygulanan öğretim hakkındaki görüşleri nelerdir?

Çalışmanın Katılımcıları

Ortaokul beşinci sınıf öğrencileriyle yürütülen çalışmanın deney grubunda 37, kontrol grubunda 36 öğrenci yer almaktadır. Deney grubu öğrencilerinin 14'ü kız, 23'ü erkek; kontrol grubu öğrencilerinin 16'sı kız, 20'si erkektir.

Deney ve kontrol gruplarının denk olup olmadığını belirlemek için deneysel işlem sürecine başlamadan önce MT, MADÖ ve MMÖ her iki gruba uygulanarak, gruplar arasında fark olup olmadığı incelenmiştir. Elde edilen veriler SPSS 25 programı yardımıyla *t*-testler kullanılarak analiz edilmiştir. Yapılan *t*-test sonuçlarına göre, her iki grubun MT, MADÖ ve MMÖ'den aldıkları puanlar arasında anlamlı bir fark olmadığı belirlenmiş, ardından gruplardan biri deney diğeri kontrol grubu olarak rastgele bir şekilde atanmıştır.

Araştırmada nitel verilerin elde edildiği öğrenci günlükleri, deney grubunda yer alan tüm öğrencilerden toplanmıştır. Görüşmeler ise başarı testi sonucuna göre maksimum çeşitlilik örnekleme yöntemi kullanılarak belirlenen 10 öğrenci ile gerçekleştirilmiştir. Öğrencilerin sontest Matematik Testinden elde ettikleri puanlar derecelendirilerek alt ($n = 3$), orta ($n = 4$) ve üst ($n = 3$) başarı gruplarından öğrenciler belirlenmiş ve görüşmeler gerçekleştirilmiştir.

Veri Toplama Araçları

Araştırma sorularına yanıt bulmak amacıyla nicel verilerin elde edilmesi için Matematik Testi (MT), Matematikte Akış Durumu Ölçeği (MADÖ), Matematik Dersi Motivasyon Ölçeği (MMÖ); nitel verilerin elde edilmesi için ise Gözlem Formu, Öğrenci Günlükleri ve Görüşme Formu kullanılmıştır. Bu araçlar aşağıda açıklanmıştır.

Matematik Testi

MT, arařtırmacı tarafından deneysel iřlem bařlamadan nce geliřtirilmiřtir. Testin geliřtirilmesinde MEB (2017) tarafından hazırlanan Ortaokul Matematik ğretim Programında yer alan kazanımlar dikkate alınmıřtır. Kazanımlara ve biliřsel dzeylerine karar verilmesinin ardından her kazanıma ynelik en az iki maddenin yer aldıęı toplam 40 maddelik deneme formu oluřturulmuř, farklı alan uzmanlarından grř ve geri bildirim alınmıř, ardından 344 ortaokul ğrencisine deneme uygulaması yapılmıřtır.

Elde edilen verilerin test ve madde istatistikleri hesaplandıktan sonra, her kazanımı len yksek ayırt edicilik ve orta dzeyde glęe sahip birer madde seilmiřtir. Sonu olarak, 18 maddeden oluřan nihai testin KR-20 gvenirlik katsayısı 0.75, ortalama glę 0.52, ortalama ayırt edicilięi 0.49 olarak bulunmuřtur.

Matematik Dersi Akıř Durumu leęi

MAD (Bkz. Ek J), Eryılmaz ve Mammadov (2016a) tarafından geliřtirilmiř olup, 4'l likert tipinde bir lektir. lek, Akıř, Sıkılma ve Kaygı olmak zere 3 alt boyut ve bu boyutları len 13 maddeden oluřmaktadır. Arařtırmacılar, faktrler arasındaki korelasyonların anlamlı olmaması nedeniyle leęin toplam puanı yerine faktrleri aısından kullanılmasını nermiřlerdir. leęin geliřtirilmesinde, 14-18 yař grubunda yer alan lise ğrencilerinden veri toplandıęı iin, leęin 5. Sınıf yař dzeyine uygunluęunu belirlemek adına uyarlama alıřması yapılmıřtır. Bu amala lek, bu alıřmada yer alan ğrencilerin dıřında, 5. sınıf 380 ğrenciye uygulanarak AFA ve DFA analizleri yapılmıřtır.

AFA sonularına gre, MAD'nn 13 maddesi iin temel yapıyı deęerlendirmek iin varimax rotasyonlu temel eksen faktr analizi yapılmıřtır. Maddelerin akıř, sıkılma ve kaygı olmak zere  yapıyı endeksleyecek řekilde tasarlandıęı gereęinden hareketle  faktr istenmiřtir. Buna gre, 1. Faktr iin faktr ykleri .496 ile .785 arasında, 2. Faktr iin .566 ile .709 arasında, 3. Faktr iin .536 ile .709 arasında elde edilmiř ve bu deęerler anlamlı bulunmuřtur (Hair ve dię., 2010) bunlar anlamlıydı (Hair ve ark.,

2010). Döndürmeden sonra 1. faktör varyansın %19.42'sini, 2. faktör %16.96'sını ve 3. faktör %14.36'sını açıklamıştır.

DFA sonuçları, akış, sıkılma ve kaygı faktörlerinin “Akış Durumu” adı verilen bir yapının bileşenleri olduğunu doğrulamaktadır. Uyum iyiliği indeksleri; $X^2= 165.51$; $X^2/df = 2.67$; $p = 0,00$; ECVI = 0,59; NFI = 0.96; NNFI = 0.97; CFI = 0.97; EFE = 0.97; GFI = 0.94; AGFI = 0.91 ve RMSEA = 0.066 olarak elde edilmiştir. İndekslerin bu değerleri ölçüm modelinin kabul edilebilir olduğunu kanıtlamaktadır (Schermele-Engel ve Müller, 2003).

Ölçekte yer alan akış, sıkılma ve kaygı boyutlarına ilişkin Cronbach Alpha iç tutarlılık katsayıları sırasıyla .78, .77 ve .85 olarak elde edilmiştir.

Matematik Motivasyon Ölçeği

MMÖ (Bkz. Ek K), Tahiroğlu ve Çakır (2014) tarafından geliştirilmiş bir ölçek olup, ölçeğin geliştirilme aşamasında araştırmacılar 299 dördüncü sınıf öğrencisinden veri toplayarak analizleri gerçekleştirmişlerdir. 5'li likert tipinde olan ölçek toplam 5 faktör ve 32 maddeden oluşmaktadır. Faktörler; takdir edilmeye yönelik, ilgi istek ve ihtiyaçlara yönelik, özgüven geliştirmeye yönelik, başarılı olmaya yönelik, ve hedeflere yönelik güdülenme şeklindedir. Faktörlere ait Cronbach Alpha güvenilirlik katsayıları sırasıyla .91, .92, .89, .85 ve .70 olup, ölçeğin toplam güvenilirlik katsayısı .93 olarak elde edilmiştir.

Görüşme Formu

Akış Kuramına dayalı matematik öğretimi alan öğrencilerin, öğretim süreci, etkinlikler ve deneyimleri hakkında görüşlerini öğrenmek amacıyla yarı yapılandırılmış bir görüşme formu hazırlanmıştır. Bu form 11 açık uçlu sorudan oluşmaktadır. Formun hazırlanmasında soruların uygunluğunu belirlemek amacıyla farklı alanlardan beş uzmanın görüşleri alınmış, ardından 5. Sınıf üç öğrenciyle deneme uygulaması yapılmıştır. Yanlış anlaşılma ya da anlaşılama ihtimali olan ifadeler düzenlenerek formun son hali belirlenmiştir (Bkz. Ek L).

Gözlem Formu

Araştırmacı, öğrencilerin etkinliklere yönelik davranışlarını, öğrenciler arasındaki ilişkiyi ve öğretmenin öğretimini gözlemek için deney sürecinde sınıfta hazır bulunmuştur. Bu amaçla araştırmanın araştırma soruları doğrultusunda bir çerçeve hazırlanmış ve araştırmacı tarafından kullanılmıştır (Bkz. Ek M).

Öğrenci Günlükleri

Araştırmada öğrencilerden haftalık olarak matematik dersleri ile ilgili günlük yazmaları istenmiştir. Diğer veri toplama araçlarından elde edilecek verilerin çeşitlenmesinde öğrenci günlüklerinden yararlanılmıştır. Bu amaçla literatürde kullanılan günlükler incelenmiş ve öğrencilerden matematik derslerinde neler hissettikleri, etkinliklerle ilgili düşünceleri ve derste neler öğrendikleri hakkında kısaca yazmaları istenmiştir. Günlükler öğrencilerden haftalık olarak toplanmış ve bilgisayara aktarılmıştır.

Deneysel İşlem Materyali

Çalışmanın yapılacağı süreçte yıllık planda yer alan kazanımların öğretilmesi amacıyla araştırmacı tarafından öğretim tasarlanmış ve gerekli tüm etkinliklerle materyaller hazırlanmıştır. Bu aşamada Akış Kuramının ilkeleri temele alınmış, aynı zamanda GME yaklaşımından yararlanılarak öğretim süreci zenginleştirilmiştir. Alanyazın incelendiğinde, bir öğretim tasarımı yapılırken Akış Kuramı ilkelerinin nasıl kullanılabileceğine dair hiçbir örneğe rastlanamamıştır. Ancak kuramla ilgili yapılan bazı çalışmalarda araştırmacılar farklı sınıflarda öğretim yapan öğretmenlerin davranışları, kullandıkları öğretim stratejileri üzerinde detaylı gözlemler yapmış, ardından bu unsurlardan hangilerinin öğrencilerde daha fazla akış deneyimi ve motivasyon sağladığına ilişkin çıkarımlarda bulunmuşlardır (Challco et al., 2016; Gunderson, 2003; Schweinle, Turner ve Meyer, 2006; Su ve Hsaio, 2015; Turner ve diğ., 1998). Akış Kuramının ele alındığı eğitim ve öğretimle ilgili çalışmalarda genellikle uygulanan öğretimin öğrencilerde ne derece akışa neden olduğu (Ak-Şentürk, 2010; Armstrong, 2008) ya da kullanılan bazı tekniklerin akış deneyimine katkı sağlayıp sağlamadığı (Admiraal, Huizenga, Akkerman & Dam, 2011; Alperer,

2005; Aremu & Adebago, 2016; Chan & Ahern, 1999; Kalay, 2013; Su & Hsaio, 2015) üzerine bulgulara erişildiği görülmektedir. Tüm bu çalışmalardan elde edilen bulgular doğrultusunda araştırmacı tarafından çıkarımlarda bulunulmuş ve Akış Kuramına dayalı bir öğretim tasarımının sahip olması gereken özellikler belirlenmiştir. Ardından, bu özellikler matematik öğretimine uyarlanarak 11 haftalık bir öğretim tasarımı hazırlanmış, bu noktada bir matematik eğitimi yaklaşımı olan ve Akış Kuramı ile birbirini destekleyen özelliklere sahip olan GME'den yararlanılmıştır.

Hazırlanan öğretim tasarımında kullanılacak etkinlik ve materyaller, Eğitim Programları ve Öğretim alanından iki, Bilgisayar ve Öğretim Teknolojileri Eğitiminden bir uzmanın ve üç ilköğretim matematik öğretmenin görüşüne sunulmuştur. Uzmanlar içerik, etkinliklerin kazanımlara uygunluğu, öğrencilerin gelişim düzeyleri, kullanılan dil gibi konularda geribildirimlerde bulunmuş, bu geribildirimler doğrultusunda kullanılacak süre, gerçek yaşam durumlarında kullanılan örnekler, etkinliklerde kullanılan problemler, şekil ve tablolarda gerekli düzenlemeler yapılmıştır.

Etkinliklerin ve ders planlarının hazırlanmasında kullanılan öğretim stratejileri şu şekildedir: Beceri ve zorluk düzeyi arasındaki dengenin sağlanması, geribildirim sağlama, öğrenen özerkliğini destekleme, olumlu duyguları teşvik etme, sosyal ilişkileri destekleme, içeriği öğrenenler için uygun ve ilgi çekici hale getirme. Bu özelliklerin bazıları farklı şekillerde veya miktarlarda herhangi bir sınıf ortamında yer alıyor olabilir. Ancak, Schweinle ve diğerlerine (2006) göre, Akış Kuramına dayalı öğretim ortamlarında bu unsurların motivasyonu ve akış durumunu sağlayabilmesi için mümkün olduğunca birlikte yer alması gerekmektedir.

Verilerin Toplanması

Bu çalışma 2017-2018 bahar yarıyılında, ortaokul 5. sınıf matematik dersinde 11 hafta boyunca sürdürülmüştür. Deneysel işlemde önce, her iki grubun arasında fark olup olmadığını belirlemek için öğrencilere MT, MADÖ ve MMÖ uygulanmıştır. Yapılan analizler sonucu gruplar arasında herhangi bir fark olmadığı belirlenmiştir. Ardından rastgele bir şekilde gruplardan biri deney diğeri kontrol grubu olarak seçilmiştir. 11 haftalık uygulama boyunca araştırmacı deney grubunda yapılan öğretimi gözlemlemiştir.

ve gözlem formu kullanarak notlarını kaydetmiştir. Bu süreçte deney grubu öğrencilerinden her hafta uygulanan matematik öğretimi, etkinlikler ve materyaller hakkında günlük yazmaları istenmiştir. Deneysel işlemin tamamlanmasının hemen ardından deney ve kontrol gruplarına MT, MADÖ ve MMÖ sonestleri uygulanmıştır. MT'den elde edilen veriler analiz edilmiş ve üst, orta ve alt başarı düzeyinden toplam 10 öğrenci belirlenerek bu öğrencilerle yarı yapılandırılmış görüşmeler gerçekleştirilmiştir. Görüşmeler okulda bulunan boş bir odada yapılmış ve ses kayıt cihazı yardımıyla kayıt altına alınmıştır. Deneysel uygulamanın üzerinden dört ay geçtikten sonra, araştırmacı tarafından MT kalıcılığı belirlemek adına tekrar uygulanmıştır.

Verilerin Analizi

Nicel Verilerin Analizi

Grupların deney öncesinde aralarında fark olup olmadığını belirlemek için bağımsız örneklem için t testinden yararlanılmıştır. Birinci araştırma sorusuna yanıt bulabilmek için, Matematik Testinden elde edilen veriler 3x2 tekrarlı ölçümler için karma ANOVA ile analiz edilmiştir. İkinci ve üçüncü araştırma sorularına yanıt bulmak amacıyla MADÖ ve MMÖ'den elde edilen veriler 2x2 tekrarlı ölçümler için karma ANOVA kullanılarak analiz edilmiştir. Ardından, bazı anlamlılık değerlerini yorumlayabilmek için ilişkili örneklem ve bağımsız örneklem için t -testleri kullanılmıştır.

Nitel Verilerin Analizi

Yarı yapılandırılmış görüşmeler, gözlemler ve öğrenci günlüklerinden elde edilen nitel verilerin analizinde tümevarımsal ve tümdengelsel tematik analiz yöntemi kullanılmıştır. Tematik analiz gerçekleştirilirken, Braun ve Clarke (2006) tarafından önerilen altı aşamadan oluşan analiz tekniği kullanılmıştır. Bu aşamalar sırasıyla "1. Veriye aşına olma, 2. İlk kodların oluşturulması, 3. Temaların aranması, 4. Temaların gözden geçirilmesi, 5. Temaların tanımlanması ve isimlendirilmesi ve 5. Raporun hazırlanması" şeklindedir. Veriye aşına olma adımında araştırmacı tüm veri toplama sürecine dahil olmuş, deneysel işlem boyunca gözlemler yapmış ve öğrencilerle yarı

yapılandırılmış görüşmeleri gerçekleştirmiştir. Ardından araştırmacı, elde edilen tüm nitel veri setini bilgisayar ortamına aktararak, baştan sona birkaç defa okumuştur. İlk kodların oluşturulması adımı araştırmacı öncelikle veriden yola çıkarak kodlar oluşturmuş, ardından alanyazında var olan kodlarla bu kodlar ilişkilendirilerek bir kod kitabı oluşturulmuştur. Oluşturulan kodlar eğitim bilimleri bölümünde görev yapan, nitel araştırma hakkında deneyimli ve doktora tezini bu yaklaşımla tamamlamış olan bir uzmanla paylaşılmış, iki araştırmacı kodlar üzerinde tartışarak benzerlik ve farklılıklar hakkında uzlaşmış ve kod kitabı düzenlenmiştir. Sonuç olarak iki kodlayıcı arasında %83 uyum olduğu belirlenmiştir. Kodlayıcılar arası %80 ve üzeri güvenilirliğin elde edilmesi yeterli olarak kabul gördüğünden (Miles ve Huberman, 1994) bu kod listesi ile çalışmaya devam edilmiştir. Temaların aranması adımı, araştırmacı kodları yeniden analiz ederek olası temalar altında gruplandırmayı amaçlamıştır. Bu adımda, kod ve temaların belirlenmesinde Csikszentmihalyi, Latter ve Duranso (2017) tarafından Akış Teorisinin temel ilkelerinin öncülleri ve sonuçları olarak yapılan tanımları ve gruplandırılması kullanılmıştır. Temaların gözden geçirilmesi adımı araştırmacı belirlenen olası temaları yeniden incelemiş ve bazı temaların birleştirilmesi, bazılarının ise diğer temalar altında alt temalar olarak yer alması gerektiğine karar vermiştir. Araştırmacı, veri setini yansıtan tatmin edici bir tematik haritaya ulaşana kadar temaları incelemeye devam etmiştir. Temaların tanımlanması ve isimlendirilmesi adımı her bir temanın ve alt temaların veri setinin hangi boyutunu yansıttığını tanımlamıştır. Daha sonra bu temalar için kısa, öz, dikkat çekici ve anlaşılır isimler belirlenmiştir. Ayrıca tema ve alt temaların birbiriyle örtüşüp örtüşmediğine bakılmış ve temaların temsil ettiği veriler analiz edilmiştir (Braun ve Clarke, 2006). Miles ve Huberman'ın (1994) her temanın kendi içinde homojen olması ve diğer temaların birbirinden ayrı olması gerektiği görüşünden hareketle bu durum tüm temalar ve alt temalar için kontrol edilmiştir.

Bulgular

Öğretimin Matematik Başarısı ve Kalıcılık Üzerinde Etkisine İlişkin Elde Edilen Bulgular

Araştırmanın birinci alt problemi, deney ve kontrol gruplarının başarı ve kalıcılık testi puanları arasında anlamlı bir fark olup olmadığını belirlemeye yöneliktir. Bu araştırma problemine yanıt bulabilmek amacıyla gerçekleştirilen tekrarlı ölçümler için karma ANOVA sonuçları, ölçüm zamanı ana etkisinin istatistiksel olarak anlamlı olduğunu ortaya koymuştur, $F(1.524, 108.204) = 159.21, p = .000$. Cohen'e (1988) göre $\eta^2 > .20$ olduğundan, elde edilen etki büyüklüğü yüksek veya kuvvetli olarak sınıflandırılabilir. Diğer taraftan, ANOVA sonuçları grup ana etkisinin istatistiksel olarak anlamlı olmadığını ortaya koymaktadır, $F(1, 71) = 1.422, p = .24$. ANOVA sonuçlarından elde edilen bir diğer sonuç ise, ölçüm zamanı ve grup etkileşiminin istatistiksel olarak anlamlı olduğu şeklindedir, $F(1.524, 108.204) = 4.398, p < .05$.

Ölçüm zamanı ana etkisi anlamlı bulunduğu için, bu farkın nereden kaynaklandığını belirlemek amacıyla Bonferroni düzeltmeleri kullanılarak ikili karşılaştırmalar yapılmıştır. Yapılan ikili karşılaştırmalar, deney grubunun elde etmiş olduğu öntest-sontest ($p < .001$), sontest-kalıcılık testi ($p < .05$), ve öntest-kalıcılık testi ($p < .001$) matematik puanları arasındaki farkın istatistiksel olarak anlamlı olduğunu ortaya koymaktadır. Diğer taraftan, kontrol grubunun elde etmiş olduğu öntest-sontest ($p < .001$) ve öntest-kalıcılık testi matematik puanları arasındaki fark anlamlı bulunurken, sontest-kalıcılık testi ($p > .05$) puanları arasındaki farkın istatistiksel olarak anlamlı olmadığı belirlenmiştir. Buna göre, deney grubunda uygulanan öğretim, öğrencilerin sontest ve kalıcılık testindeki matematik puanları üzerinde etkili olurken, kontrol grubunda uygulanan öğretim sadece sontest matematik puanları üzerinde anlamlı bir etkiye neden olmuştur.

Etkileşim etkisinin anlamlı çıkmasını sağlayan farklılıkların belirlenmesi için ilk olarak deney ve kontrol gruplarının öntest ile sontest puanları karşılaştırılmıştır. Buna göre, deney ve kontrol gruplarının öntest ile karşılaştırıldığında sontestten aldıkları puanlar arasında anlamlı bir fark olmadığı belirlenmiştir, $F(1,71) = .548, p > .05$.

İkinci olarak, deney ve kontrol gruplarının sontest ile kalıcılık testi puanları karşılaştırılmıştır. Buna göre, deney ve kontrol gruplarının sontest ile karşılaştırıldığında kalıcılık testinden aldıkları puanlar arasında istatistiksel olarak anlamlı bir fark olduğu belirlenmiştir, $F(1,71) = 9.491, p < .05$. Bu farka göre, deney grubunun sontestle karşılaştırıldığında kalıcılık testinden aldığı puanlar, kontrol grubunun aldığı puanlardan anlamlı olarak daha yüksektir.

Öğretimin Matematikte Akış Durumu Üzerinde Etkisine İlişkin Elde Edilen Bulgular

Araştırmanın ikinci alt problemi, deney ve kontrol gruplarının Akış Durumu Ölçeğinden elde ettikleri puanlar arasında anlamlı bir fark olup olmadığını belirlemeye yöneliktir. Akış Durumu Ölçeğinin alt boyutları olan Akış, Sıkılma ve Kaygıya ilişkin elde edilen puanlar, tekrarlı ölçümler için karma ANOVA ile ayrı ayrı analiz edilerek bulgular sunulmuştur.

Akış Alt-Boyutuna İlişkin Elde Edilen Bulgular

Yapılan ANOVA analizi sonuçlarına göre, ölçüm zamanı ana etkisinin istatistiksel olarak anlamlı olduğu belirlenmiştir, $F(1, 71) = 19.39, p = .000$. Cohen'e (1988) göre $\eta^2 > .20$ olduğundan, elde edilen etki büyüklüğü yüksek veya kuvvetli etki olarak sınıflandırılabilir. Bu etki, grup değişkeni göz ardı edildiğinde, bazı ölçüm zamanlarının diğerlerinden önemli ölçüde farklılaştığını göstermektedir. Ayrıca, ANOVA sonuçları, grup ana etkisinin istatistiksel olarak anlamlı olmadığını göstermiştir, $F(1, 71) = 3.10, p = .083, \eta^2 = .04$. Sonuçlar ayrıca ölçüm zamanı ile grup etkileşiminin istatistiksel olarak anlamlı olmadığını ortaya koymaktadır, $F(1, 71) = 3.55, p = .064, \eta^2 = .05$.

Ölçüm zamanı ana etkisi anlamlı bulunduğu için, bu farkın nereden kaynaklandığını belirlemeye ihtiyaç vardır. Bu amaçla, deney ve kontrol gruplarının sontest puanları arasında fark olup olmadığını belirlemek için bağımsız örneklem t -testi; grupların öntest ve sontest puanları arasında fark olup olmadığını belirlemek için ilişkili örneklem t -testi kullanılmıştır.

Bağımsız örneklemeler t -testi sonucuna göre, deney ve kontrol gruplarının sontest Akış Alt-Boyutu puanları arasında deney grubu lehine anlamlı bir fark vardır $t(71) = 2.32$, $p < .05$. Cohen'e (1988) göre, bu fark küçük veya zayıf bir etkiye sahiptir ($d = .22$). İlişkili örneklemeler t -testi sonucuna göre, deney grubu öğrencilerinin Akış Alt-Boyutuna ilişkin son test puanlarının, öntest puanlarından anlamlı olarak daha yüksek olduğu belirlenmiştir, $t(36) = 5.17$, $p = .000$. Cohen'e (1988) göre bu farklılık büyük etki değeri göstermektedir ($d = .84$). Ancak, kontrol grubuna ilişkin öntest ve sontest Akış Alt-Boyutu puanlarının anlamlı bir fark göstermediği belirlenmiştir, $t(35) = 1.58$, $p > .05$. Elde edilen bu bulgular, deney grubunda uygulanan öğretimin öğrencilerin sontest Akış alt boyutu puanlarını artırmada etkili olduğunu, ancak kontrol grubunda uygulanan öğretimin sontest Akış alt boyutu puanları üzerinde anlamlı bir etkisi olmadığını göstermektedir.

Sıkılma Alt Boyutuna İlişkin Elde Edilen Bulgular

Sıkılma alt boyutuna ilişkin elde edilen ANOVA analizi sonuçlarına göre, ölçüm zamanı ana etkisinin istatistiksel olarak anlamlı olduğu belirlenmiştir, $F(1, 71) = 5.64$, $p < .05$. Cohen'e (1988) göre $\eta^2 = .074$ olduğundan, elde edilen etki büyüklüğü orta düzey olarak sınıflandırılabilir. Bu etki, grup değişkeni göz ardı edildiğinde, bazı ölçüm zamanlarının diğerlerinden önemli ölçüde farklılaştığını göstermektedir. ANOVA sonuçları, grup ana etkisinin istatistiksel olarak anlamlı olmadığını göstermiştir, $F(1, 71) = .25$, $p > .05$. Bu etki ölçüm zamanı göz ardı edildiğinde, deney grubunun Sıkılma alt-boyutu puanlarının kontrol grubundan anlamlı olarak farklı olmadığını göstermektedir. Ayrıca, sonuçlar ölçüm zamanı ile grup etkileşiminin istatistiksel olarak anlamlı olmadığını göstermektedir, $F(1, 71) = 1.35$, $p > .05$.

Ölçüm zamanı ana etkisi anlamlı bulunduğu için, bu farkın nereden kaynaklandığını belirlemeye ihtiyaç vardır. Bu amaçla, deney ve kontrol gruplarının sontest puanları arasında fark olup olmadığını belirlemek için bağımsız örneklemeler t -testi; grupların öntest ve sontest puanları arasında fark olup olmadığını belirlemek için ilişkili örneklemeler t -testi kullanılmıştır.

Bağımsız örneklemeler t -testi sonucuna göre, deney ve kontrol gruplarının sontest Sıkılma alt-boyutu puanları arasında anlamlı bir fark yoktur, $t(71) = 1.01$, $p > .05$.

İlişkili örneklemeler t -testi sonucuna göre, deney grubu öğrencilerinin Sıkılma alt-boyutuna ilişkin son test puanlarının, öntest puanlarından anlamlı olarak daha düşük olduğu belirlenmiştir, $t(36) = 2.63, p < .05$. Ancak, kontrol grubuna ilişkin öntest ve sontest Sıkılma alt-boyutu puanlarının anlamlı bir fark göstermediği belirlenmiştir, $t(35) = .82, p > .05$. Elde edilen bu sonuçlar, deney grubunda uygulanan öğretimin öğrencilerin sontest Sıkılma alt-boyutu puanları üzerinde anlamlı etkisi olduğunu, ancak kontrol grubunda uygulanan öğretimin öğrencilerin sontest Sıkılma alt-boyutu puanları üzerinde anlamlı bir etki yaratmadığını göstermektedir.

Kaygı Alt-Boyutuna İlişkin Elde Edilen Bulgular

Kaygı alt-boyutuna ilişkin elde edilen karma ANOVA sonuçlarına göre, ölçüm zamanı ana etkisinin istatistiksel olarak anlamlı olmadığı belirlenmiştir, $F(1, 71) = 3.75, p = .057$. Buna göre, grup değişkeni göz ardı edildiğinde ölçüm zamanlarının birbirinden önemli ölçüde farklılaşmadığı söylenebilir. Ayrıca ANOVA sonuçları grup ana etkisinin istatistiksel olarak anlamlı olmadığını göstermiştir, $F(1, 71) = .02, p > .05$. Bu etki, ölçüm zamanı göz ardı edildiğinde grupların Kaygı alt-boyutu puanlarının anlamlı olarak farklılaşmadığını göstermektedir. Ayrıca, sonuçlar ölçüm zamanı ile grup etkileşiminin istatistiksel olarak anlamlı olmadığını göstermektedir, $F(1, 71) = 2.58, p > .05$. Buna göre, iki ölçüm zamanında alınan Kaygı alt-boyutuna ilişkin puanlar deney ve kontrol grubu için farklılık göstermemiştir.

Öğretimin Matematik Motivasyonu Üzerinde Etkisine İlişkin Elde Edilen Bulgular

Araştırmanın üçüncü alt problemi, deney ve kontrol gruplarının Matematik Dersi Motivasyon Ölçeğinden elde ettikleri puanlar arasında anlamlı bir fark olup olmadığını belirlemeye yöneliktir. Karma ANOVA sonuçlarına göre, zaman ana etkisinin istatistiksel olarak anlamlı olmadığı belirlenmiştir, $F(1, 71) = .96, p > .05$. Buna göre, grup değişkeni ihmal edildiğinde, ölçüm zamanlarının önemli ölçüde bir fark göstermediği söylenebilir. Benzer şekilde, ANOVA sonuçlarına göre grup ana etkisinin istatistiksel olarak anlamlı olmadığı belirlenmiştir, $F(1, 71) = .61, p > .05$. Elde edilen bu bulgu, ölçüm zamanlarının ihmal edildiği durumda, grupların matematik motivasyonu puanları arasında anlamlı bir fark olmadığına işaret

etmektedir. Ancak, ANOVA sonuçlarına göre, ölçüm zamanı ile grup etkileşiminin istatistiksel olarak anlamlı olduğu belirlenmiştir, $F(1, 71) = 8.99, p < .05$. Elde edilen etki büyüklüğü için $\eta^2 = .11$ olduğundan, bu etki orta düzey olarak sınıflandırılabilir (Cohen, 1988; Leech et al., 2008: p. 81). Bu sonuç iki farklı ölçüm zamanından elde edilen matematik motivasyonuna ilişkin puanların, deney ve kontrol grubu öğrencileri için farklılaştığını göstermektedir. Ortaya çıkan bu anlamlı ilişki, son test puanları, ön test puanlarıyla karşılaştırıldığında, deney grubunun matematik motivasyonu puanlarının kontrol grubundan istatistiksel olarak daha yüksek olduğunu ortaya koymaktadır.

Deney Grubu Öğrencilerinin Öğretim Hakkında Görüşleri

Dördüncü araştırma sorusu, deney grubunda yer alan öğrencilerin uygulanan öğretim hakkındaki görüşlerini incelemeyi amaçlamaktadır. Bu amaç doğrultusunda, görüşmeler, sınıf gözlemleri ve öğrenci günlüklerinden elde edilen veriler tematik analiz yöntemiyle çözümlenmiştir. Tematik analiz sonuçlarına göre iki ana kategori belirlenmiş olup, bu kategoriler *Özellikler* ve *Etkiler* şeklinde etiketlenmiştir. *Özellikler* kategorisi altında *Matematik öğretiminin özellikleri* ve *Öğretmen özellikleri* şeklinde iki tema ortaya çıkmıştır. *Etkiler* kategorisi altında ise *Motivasyonla ilgili etkiler*, *Bilişsel etkililiğe yönelik etkiler* ve *Sosyal etkiler* şeklinde üç tema belirlenmiştir. Belirlenen bu temalardan bazıları alt temalara ayrılmaktadır.

Özellikler

Tematik analiz sonuçlarına göre, deney grubunda uygulanan öğretimin *zorluk*, *açık hedefler*, *anında geribildirim*, *özerklik/kontrol hissi* ve *ilgi* şeklinde bazı özelliklere sahip olduğu belirlenmiştir. Bunlardan ilki olan zorluk hakkında ortaya çıkan bulgulara göre, derste yapılan etkinliklere ilişkin zorluk düzeyinin genel olarak öğrencilerin beceri düzeylerine uygun olduğu ifade edilmiştir. Öğrenciler katıldıkları etkinliklerin genel olarak orta düzeyde zorluğa sahip olduğunu, bazılarının daha fazla zorlayıcı, bazılarının ise daha kolay olduğunu belirtmişlerdir. Öğrencilerden birinin görüşme esnasında verdiği yanıt şu şekildedir:

Matematik dersinde beni motive eden şey problemler, ve daha çok zor, zeka problemleridir. Ben zorluğu daha çok seviyorum. Basitlerde hep

işlediğimiz şeyler, ve daha çok önceden öğrendiğimiz, yaptığımız şeyler. Ama zor görevlerle uğraşarak kendimi daha çok geliştiriyorum. (S2-Düşük Akademik Başarılı Öğrenci-Görüşme)

Deney grubunda uygulanan öğretimin bir diğer özelliği, açık ve anlaşılır hedeflere sahip olmasıdır. Nitel verilerden elde edilen bulgularda öğrencilerin derslerde yapılan etkinliklerin ne amaçla yapıldığını, kendilerinden beklenen şeyin ne olduğunu ve süreç sonunda neyi öğreneceklerini kolaylıkla görebildikleri belirlenmiştir. Bu bulguyla ilgili elde edilen bazı öğrenci görüşleri şu şekildedir:

Dersin amacını, öğretmenimizin anlatımıyla anlıyordum. En başta o bize neden bu etkinliği yaptığımızı açıklıyordu. Etkinliğe geçtiğimizde zaten orda da yazıyordu ne yapacağımız, mesela “bir robot tasarlayın” şeklinde. Sonra, etkinlik kağıdında şekiller, resimler oluyordu, oradan anlıyordum amacımızın ne olduğunu. (S7, Düşük Akademik Başarılı Öğrenci, Görüşme)

Yapılan öğretimde dikkat çeken bir diğer özellik ise öğrencilere ihtiyaç anında açık ve anlaşılır geribildirim sağlanmasıdır. Deney grubunda yer alan öğrenciler, ihtiyaç duydukları zaman hem arkadaşlarından hem de öğretmenden yardım talep edebildiklerini ve yardım isteyen arkadaşlarının da bu taleplerini yerine getirdiklerini ifade etmişlerdir. Bu konuda sınıf gözlemlerinden elde edilen bazı bulgular şu şekildedir:

Öğretmen, gruplar arası sınıf tartışması yapılırken, bir grubun verdiği cevap üzerinden yola çıkarak ‘Arkadaşlarınızın bu yanıtı hakkında görüş belirtmek isteyen var mı?’ şeklinde tüm sınıfa sorular yönelterek, diğer öğrencilerin verilen cevaplara geri bildirim vermesi, düzeltmeler yapması için olanak sağladı. (O2, Gözlem)

Deney grubunda uygulanan öğretimin sahip olduğu bir diğer özellik, öğrencilere bu derslerde kontrol veya özerklik hissi sağlanıyor olmasıdır. Öğrenciler kendi kararlarını vermeleri, risk almaktan ve hata yapmaktan çekinmemeleri konusunda teşvik edilmiş, görüşlerini özgür bir şekilde ifade edebilmişlerdir. Bu konuyla ilgili elde edilen bazı ifadeler şu şekildedir:

İstediğimiz şeyi yapabiliyorduk, mesela, öğretmenimiz bizi kısıtlamıyor, çünkü yanlış yaparsak bile kızıyor, kısıtlamıyor, ‘sakın yanlış yapmayın’ demiyordu. Bu yüzden kendimi çoğu zaman özgür hissediyordum. (S10, Orta Düzey Akademik Başarılı Öğrenci, Görüşme)

Son olarak, deney grubunda uygulanan öğretim öğrencilerin ilgisini çekici bazı özelliklere sahiptir. Etkinliklerde kullanılan materyaller ve teknolojik araç gereçler, gerçek yaşamdan örnekler, fiziksel aktivite gibi unsurlar öğrencilerin derse daha fazla ilgi göstermesini sağladığı belirlenmiştir. Bu bulguları örnekleyen bazı öğrenci ifadeleri şu şekildedir:

Derste yaptığımız robot tasarımları ve yelkenli tasarımları benim çok ilgimi çekiyor. Tasarım yaptığım, mühendislik gerektiren çalışmalarda çok eğleniyorum. (S3, Yüksek Düzey Akademik Başarılı Öğrenci, Görüşme)

Özellikler kategorisi altında ele alınan diğer tema, öğretmene atfedilen özellikler olarak belirlenmiştir. Deney grubu öğrencileri öğretimi gerçekleştiren öğretmenin olumlu duyguları destekleyen ve iyi bir öğretim tekniği olduğunu belirten ifadeler kullanmışlardır. Öğrenciler gerek görüşmelerde gerekse günlüklerde öğretmen özelliklerini hoşgörülü, sabırlı, sevecen, eğlenceli, öğrencilerini seven, ilgili ve yardımsever gibi sözcüklerle tanımladıkları görülmektedir. Yapılan gözlemlerden elde edilen sonuçlar da bu durumu desteklemektedir. Öğretmenin sahip olduğu olumlu duygulara örnek olarak şu ifadelere yer verilebilir:

Öğretmen öğrencilerle birebir ilgilenerken, anlamadıkları noktalar hakkında açıklamalar yaptı. (O2, Gözlem)

Diğer taraftan öğrenciler genel olarak öğretmenin öğretim tekniği ile ilgili iyi, etkili, akıcı, güzel, keyifli gibi ifadelerle tanımlamışlardır. Öğretmenin kullandığı öğretim tekniğinin bu olumlu özelliklere sahip olması, onların matematik dersini eğlenceli bulmasını ve öğrenme için hevesli olmalarını sağlamıştır. Öğrenci günlüklerinden elde edilen bazı öğrenci ifadeleri şu şekildedir:

İyi ki böyle iyi ve güzel öğretmenim var. Öğretmenimi çok seviyorum. Ders ve konu anlatımı benim için çok iyi. (D20, Öğrenci Günlüğü)

Etkiler

Tematik analiz sonucunda deney grubunda uygulanan öğretimin motivasyonla ilgili, bilişsel etkililiğe yönelik ve sosyal yönden etkileri olduğu belirlenmiştir.

Motivasyonel Etkiler

Yapılan öğretim etkinliklerinin içsel ve dışsal olmak üzere farklı motivasyon unsurlarına etki ettiği görülmektedir. İçsel motivasyon alt temasına göre, deney grubunda uygulanan öğretimin öğrencilerin öğrenme etkinliklerine, etkinliğin kendisi için katılmalarında (*ototelik olması*) ve matematiği öğrenmek için gösterdikleri çabanın artmasında etkili olduğu belirlenmiştir. Öğrenciler matematik derslerinde iyi hissettikleri, eğlendikleri ve mutlu oldukları için katıldıklarını belirtmişlerdir. Etkinlikleri yapmaktan keyif aldıklarını, bu nedenle matematik dersine severek katıldığını belirten öğrenciler, bu duygularını şu şekilde ifade etmişlerdir:

Etkinlik yaparken eğlendiğim için başka bir şey yapmak istemiyordum. Daha çok matematik öğrenmek istiyordum, daha çok bilgi edinmek istiyordum. (*S10, Orta Düzey Akademik Başarılı Öğrenci, Görüşme*)

İçsel motivasyon alt temasıyla ilgili ortaya çıkan bir diğer bulgu, deney grubunda uygulanan öğretimin öğrencilerin matematik öğrenme çabalarını artırmaya yardımcı olduğu şeklindedir. Öğrenciler matematik karşı daha fazla istekli olduklarını, matematik öğrenme için gösterdikleri çabanın arttığını şu şekilde ifade etmektedirler:

Matematik dersi için harcadığım çaba, bu etkinlikler sayesinde arttı. Eğlendiğim için evde daha fazla matematik çalıştım. (*S1, Düşük Akademik Başarılı Öğrenci, Görüşme*)

Dışsal motivasyonla ilgili ortaya çıkan bulgularda ise, öğrencileri motive eden şeylerin matematik dersinden daha yüksek not alma ve birinin takdirini kazanma şeklinde ifade edildiği belirlenmiştir. Öğrencilerin bu alt tema ile ilgili örnek ifadeleri şu şekildedir:

Beni motive eden şeyler, sınavlardan yüksek puanlar almaktır. Öğretmenin gözüne girmek de beni motive ederdi. (*S3, Yüksek Akademik Başarılı Öğrenci, Görüşme*)

Bilişsel Etkililik Üzerine Etkiler

Deney grubunda uygulanan öğretimin öğrencilerin bilişsel etkililiğine yönelik katkıları olduğuna ilişkin elde edilen sonuçlara göre, öğrencilerin matematik konularını öğrenmelerinde, etkinlikler esnasında yoğun konsantrasyon ve odaklanma sağlayabilmelerinde ve yapılan etkinlik esnasında öğrencilerin öz-bilincini ve zaman

algısını kaybetmesi şeklinde tanımlanan dalma hissinin yaşanmasında etkisi olduğunu ortaya koyan sonuçlar elde edilmiştir.

Bunlardan ilki olan öğrenme ile ilgili etkilere bakıldığında, deney grubunda uygulanan öğretim sayesinde öğrencilerin matematiği eğlenerek öğrendikleri ve etkili öğrendikleri şeklinde bulgulara ulaşılmıştır. Öğrenciler, öğrenmeyle ilgili deneyimlerini paylaşırken eğlenerek öğrendiklerini ifade etmişlerdir. Görüşmelerden ortaya çıkan bazı öğrenci ifadeleri şu şekildedir:

Bu derslerde yaptığımız etkinlikler sayesinde matematik dünyasının ne kadar eğlenceli olduğunu gördüm. Yani matematiğin eğlenerek yapılabileceğini gördüm. Matematiği eğlenerek öğreniyorum. Matematik derslerinde her zaman böyle etkinliklerle öğrenmeyi çok isterdim, olsaydı gerçekten çok güzel olurdu. Mesela matematiği kötü olanlar ona önyargılı bakıyorlar, önyargıları kalkıp, matematiğin eğlenceli dünyası olduğunu görürlerdi. (S9, Orta Düzey Akademik Başarılı Öğrenci, Görüşme)

İkincisi, öğrenciler uygulanan öğretimin etkili öğrenmede etkili olduğunu vurgulayan ifadelerde bulunmuşlardır. Bazı öğrenciler, uygulanan öğretim etkinliklerinin kolay öğrenmeyi sağladığını ifade ederken, bazıları ise konuları iyi anladıklarını, iyi öğrendiklerini, kalıcı öğrendiklerini belirtmişlerdir. Öğrencilerin görüşmelerde ve günlüklerde dile getirdikleri bazı düşünceleri şu şekildedir:

Matematik dersinde yaptığımız etkinlikler benim matematik öğrenme isteğimi çok etkiledi. Çünkü onları yaparken bir yandan eğlendik bir yandan anladık, çözerken eğlendik. Bir yandan da öğrendiklerimiz kafamızda kaldı. (S1, Düşük Akademik Başarılı Öğrenci, Görüşme)

Bu hafta matematik dersinde açılar konusunu çok iyi öğrendim. (D6, Öğrenci Günlüğü)

Aynı zamanda yapılan etkinlikler esnasında bazı öğrencilerin grup arkadaşlarının sahip olduğu hata ve kavram yanlışlarını gidermek için yardımcı olduğu görülmüştür. Bunun en çarpıcı örneği, dörtgenlerle ilgili yapılan etkinlik esnasında bir öğrencinin yamuk çokgenini, günlük hayatta kullanılan yamuk sözcüğü ile karıştırdığı görülmüş, grup arkadaşları bu öğrencinin yanlışlığını düzeltmek için açıklamada bulunmuştur:

Öğrencilerin dörtgenleri belirlerken ön bilgilerinden yararlandığı görüldü. Bu ön bilgilerden bazıları hatalı, kavram yanlışları içeriyordu. Örneğin yamuk kavramını günlük dildeki yamuk sözcüğünün anlamı olarak kullandıkları gözlemlendi. Grup içindeki arkadaşları tarafından bunun doğru

olamayacağı söylenerek tanımlarla ilgili birbirlerine geri bildirim yaptıkları görüldü. (O6, Gözlem)

Deney grubunda uygulanan öğretimin, öğrenmenin etkili olmasını sağladığı düşünülen bir diğer bulgu ise öğrenilenlerin transfer edilebilmesi ile ilgilidir. Öğrenciler bu derslerde öğrendikleri bilgi ve becerileri hem matematiğin diğer konularında ve hem de farklı derslerde kullandıklarını ve bu sayede başarılı olduklarını dile getirmişlerdir. Bazı öğrenciler bu durumu şu şekilde aktarmışlardır:

Matematik dersindeki etkinlikler benim matematik öğrenme isteğimi etkiledi. Çünkü matematikte öğrendiklerimizle diğer derslerde daha başarılı olduk. (S1, Düşük Akademik Başarılı Öğrenci, Görüşme)

Tematik analiz sonucunda elde edilen bir diğer sonuca göre uygulanan öğretim deney grubu öğrencilerinin yoğun konsantrasyon sağlamaları ve etkinliklere odaklanmaları üzerinde etkili olmuştur. Bu konuda elde edilen bazı öğrenci görüşleri ve gözlem notları şu şekildedir:

Derste arkadaşlarımın söylediklerini, yaptıkları gürültüyü hiç duymuyordum. Çünkü o anda yaptığımız etkinliklere çok konsantre oluyordum. (S5, Orta Düzey Akademik Başarılı Öğrenci, Görüşme)

Gruplar tasarımlarını yapmaya başladıklarında sınıftaki uğultu sessizliğe dönüştü ve öğrencilerin tasarımlarına yoğunlaştıkları gözlemlendi. (O1, Gözlem)

Elde edilen bir diğer bulgu da deney grubunda uygulanan öğretimin öğrencilerin *dalma* hissini yaşamaları üzerinde etkili olduğu şeklindedir. Dalma hissi, Akış Kuramı literatüründe öz-bilincin kaybolması ve zamanın hızlı geçmesi şeklinde tanımlanan kavramları kapsamaktadır. Elde edilen bu bulguları örnekleyen öğrenci ifadeleri şu şekilde verilmiştir:

Etkinlik yaparken kendimi kaptırıyordum. Teneffüsü unutuyordum, arkadaşlarımı unutuyordum, elimdeki etkinlik kağıdına dalıyordum ve sadece düşünüyordum. Bazen derste olduğumu bile unutuyordum, çünkü çok odaklanıyordum mesela bir şey yaparken. (S7, Düşük Akademik Başarılı Öğrenci, Görüşme)

Zamanın nasıl aktığını anlayamadığım zamanlar oluyordu. Derste zaman benim için su gibi akıp gidiyordu. Çok eğlenceliydi. (S6, Yüksek Akademik Başarılı Öğrenci, Görüşme)

Sosyal Etkiler.

Tematik analiz sonucunda elde edilen bir diğ er bulgu, deney grubunda uygulanan öğ retimin sosyal etkilere de sahip oldu ğ u şek lindedir. Ancak elde edilen bulgular sosyal etkilerin hem olumlu hem de olumsuz olarak ortaya çıkt ı ğ ını göstermektedir. Olumlu sosyal etkiler alt temasında *iş birli ğ i* ($f=18$) ve *demokratik tutum* ($f=4$) kodları yer alırken, olumsuz sosyal etkiler altında ise *ç atı ş ma* ($f=5$), *rekabet* ($f=3$) ve *fiziksel olanaklar* ($f=5$) ile ilgili kodlar bulunmaktadır.

İ lk olarak, deney grubunda uygulanan öğ retimin öğrencilerin iş birlikli ç alı ş malarına ve birbirlerinin öğ renmelerine olumlu anlamda etki etti ğ i belirlenmiřtir. Öğrenciler hem sınıf ortamında hem de okul dı ř ında sosyal medyayı kullanarak etkinliklerle ilgili fikirlerini paylařtıklarını, birbirlerinin öğ renmesine katkı sa ğ ladıklarını dile getirmişlerdir. Böylece öğrenciler arasında etkileş im sa ğ lanmış ve öğrenciler iş birlikli ç alı ş mayı öğ rendiklerini bildirmiřtir. Elde edilen bazı öğrenci görüşleri ř u şekildedir:

Matematik derslerinde iyi hissediyordum, arkadaşları mın destekleriyle, birlikte takım ç alı ş masıyla gitti ğ imiz için. Hem onlar beni rahatlatıyor hem de ben onları rahatlatıyordum. Her ř ey benim üstüme de ğ il, onların da üstüne de ğildi. Yardımlařarak ilerliyorduk... (S7, *Düşük Akademik Başarılı Öğrenci, Görüşme*)

Tematik analiz sonucunda ortaya ç ı kan bir diğ er olumlu sosyal etki öğrencilerin demokratik tutumlarına ilişkindir. Deney grubunda uygulanan öğ retimin öğrencilerin eşitlik ve demokrasi gibi kavramlarla ilgili algılarına katkıda bulundu ğ u belirlenmiřtir. Örne ğ in grupların etkinlikler esnasında tasarımlara nasıl karar verdiklerini açıklarken bazı öğrenciler fikirlerini ř u şekilde ifade etmiştir:

Etkinlikler sırasında herkes kendi fikrini ka ğ ıda ç iziyordu. Daha sonra biz de kendi aramızda oy vererek anlařıyorduk. Hepimiz bakıyorduk, herkes tasarımlardan birini seçiyordu. Sonuç olarak birlikte karar veriyorduk. (S4-*Yüksek Akademik Başarılı Öğrenci, Görüşme*)

Diğ er taraftan deney grubunda uygulanan öğretim esnasında özellikle grup içinde farklı görüşlerden kaynaklanan fikir ayrılı ğ ı/ç atı ş ması gibi durumların olabile di ğ i sonucuna ulařılmıştır. Öğrenciler etkinlikler esnasında bazen görüş ayrılıkları yaşadıklarını, bazı öğrencilerin kendi fikirlerini daha baskın görmesi sonucu grup üyeleri arasında münakaşaların bile yaşanabile di ğ ini aktarmışlardır. Bu fikir ç atı ş maları

ve münakaşaların nedeni olarak örneğin, görevleri eşit dağıtamamak, birbirlerinin görüşlerini dikkate almamak, grup çalışmasına yeterince katkı sağlamamak gibi durumlar olduğu belirlenmiştir. Öğrenciler bu durumlarla ilgili duygu ve düşüncelerini şu şekilde dile getirmiştir:

Görevimi yapamadığımda veya grubuma katkı sağlayamadığımda biraz stres hissettim. Arkadaşlarımın benim hakkımda kötü düşünmesinden korktum. (S9- Orta Düzey Akademik Başarılı Öğrenci, Görüşme)

Tematik analizin bir diğer sonucu, öğrencilerin etkinlikler sırasında aşırı rekabet duygusu yaşamış olmalarıdır. Rekabetçi tutumun çok fazla olmasının öğrencilerin etkinlik anında aşırı heyecan ve hırs yaşamaları, diğer grup üyeleriyle zaman zaman tartışmaları ve paylaşımlarının azalması gibi sorunlara yol açtığı görülmüştür. Bazı öğrenciler ise heyecanlı ve yüksek sesle yarışmanın etkisiyle kontrolü kaybeden grup üyelerinden rahatsızlık duyduklarını dile getirmişlerdir. Örneğin, görüşülen kişilerden biri duygularını şu şekilde ifade etmiştir:

Bazen arkadaşlarım bağırdığında kendimi kötü hissettim. Çünkü onlar ‘biz daha iyisini yapacağız, daha hızlı yapacağız’ gibi aşırı hırslı olduklarında ben hiçbir şey öğrenemiyordum. Bunu neden yapıyorlardı bilmiyorum ama o anlarda sıkılıyordum. Ayrıca sesleri giderek yükseliyordu, bu yüzden sıkılıyordum, çünkü biz böyle şeyler yapmıyorduk. (S1-Düşük Akademik Başarılı Öğrenci, Görüşme)

Son olarak, sınıf ortamının küçük ancak öğrencilerin kalabalık olması nedeniyle, fiziksel olanakların sosyal boyut üzerinde olumsuz etkiye neden olduğu belirlenmiştir. Bu nedenle etkinlikler esnasında öğrencilerin yüksek seslerden dolayı birbirlerini duyamama ve yetersiz oturma düzeni nedeniyle tahtayı görememe gibi sorunlar yaşanmıştır. Bazı öğrenciler düşüncelerini günlüklerde şu şekilde ifade etmişlerdir:

Sınıfımızda çok ses olduğu için biraz kafam karışıyor. Benim istediğim sınıfın biraz daha sessiz olması. (D20, Günlük)

Nicel ve Nitel Bulguların Özeti

Birinci araştırma probleminde deney ve kontrol gruplarının matematik başarıları ve kalıcılık puanları arasında fark olup olmadığı incelenmiştir. Buna göre, sonuçlar deney grubunun kalıcılık testi puanlarının kontrol grubuna göre anlamlı düzeyde yüksek olduğunu göstermiştir. Nitel verilerden elde edilen bazı bulgular bu sonucu

desteklemektedir. Öğrenciler etkinlikler sayesinde matematiği daha iyi öğrendiklerini, öğrenmelerinin kalıcı olduğunu, matematiği öğrenmeye yönelik çabalarının arttığını, derste öğrendikleri konuların diğer ders ve konuları da öğrenmelerini kolaylaştırdığını belirtmişlerdir.

İkinci araştırma probleminde deney ve kontrol gruplarının Akış, Sıkılma ve Kaygı Alt Boyutu puanları arasında fark olup olmadığı incelenmiştir. Sonuçlar son testte deney grubunun kontrol grubundan anlamlı olarak daha yüksek Akış alt boyutu puanlarına sahip olduğunu göstermiştir. Ayrıca deney grubunda gerçekleştirilen öğretimin öğrencilerin akış deneyimlerini artırmada etkisi olurken, kontrol grubunda gerçekleştirilen öğretimin öğrencilerin akış deneyimlerinde anlamlı bir etkisi olmamıştır. Nitel verilerden elde edilen bulgulara göre hem motivasyonel etkiler hem de bilişsel etkililik üzerindeki etkiler temalarının bu bulguyu desteklediği görülmektedir.

Deney grubunda uygulanan öğretim öğrencilerin Sıkılma alt-boyutu son test puanlarında anlamlı bir düşüş sağlarken, kontrol grubunda uygulanan öğretimin öğrencilerin sıkılma puanları üzerinde anlamlı bir etkisi olmamıştır. Ancak deney ve kontrol gruplarının sontest sıkılma alt-boyutu puanları deneysel işlem sonrasında anlamlı bir farklılık göstermemiştir. Nitel verilerden elde edilen bulgulara göre deney grubunda öğrenen öğrencilerin bu derslere daha çok keyif alarak katıldıkları, derste sıkılmadıkları, aksine öğrenirken eğlendikleri belirlenmiştir.

Elde edilen sonuçlara göre deney ve kontrol gruplarının Kaygı alt boyutu son test puanlarının anlamlı bir şekilde farklılaşmadığı belirlenmiştir. Ayrıca, her grubun ön test ve son test puanları arasında anlamlı bir farklılık yoktur. Nitel verilerden elde edilen bazı bulgular, deney grubunda öğrenen öğrencilerin kaygı ve stres gibi olumsuz duygular yaşamadıklarını, aksine derslere katılmaktan keyif aldıklarını ortaya koymaktadır. Bu durum öğrencilerin hem ön testte hem de son testte kaygı düzeylerinin düşük olduğu bulgusunu desteklemektedir.

Üçüncü araştırma problemine ilişkin sonuçlar, deney grubunun Matematik Motivasyonu sontest puanlarının öntest puanlarına göre, kontrol grubunun puanlarından anlamlı olarak daha yüksek olduğunu göstermiştir. Nitel verilerden elde

edilen bulgulara göre deney grubunda öğrenim gören öğrencilerin hem içsel hem de dışsal motivasyon deneyimlerine sahip oldukları belirlenmiştir. Öğrencilerin matematik dersine büyük bir istekle katıldıkları, derse katılmaktan keyif aldıkları, dersteki etkinliklere etkinliğin kendisi için (ototelik) katıldıkları ve bu etkinlikler sayesinde matematik öğrenme çabalarının arttığı belirlenmiştir. Ayrıca, içsel motivasyon en sık göze çarpan alt tema olurken, öğrenciler ayrıca öğretimin dışsal motivasyonları üzerinde etkisi olduğunu belirtmişlerdir. Dışsal motivasyonla ilgili bu faktörler daha çok birinin övgüsünü kazanma ve yüksek not alma beklentisi olarak karşımıza çıkmaktadır.

Deney grubunda yürütülen öğretimle ilgili öğrencilerin görüşlerini belirlemeye yönelik olan dördüncü araştırma sorusuna ilişkin bulgular, deney grubundaki öğrencilerin öğretimle ilgili genel olarak olumlu görüş, etki ve katkı bildirdiklerini göstermiştir. Tematik analiz sonuçlarına göre bulgular *özellikler* ve *etkiler* olmak üzere iki ana kategori altında ele alınmıştır.

Tartışma ve Öneriler

Öğretimin Matematik Başarısı ve Kalıcılık Üzerindeki Etkisi

Deney grubu öğrencilerinin matematik kalıcılık testi puanları kontrol grubundan anlamlı olarak yüksek bulunmuştur. Ayrıca deney grubunun matematik puanları sontestte önteste kıyasla anlamlı olarak farklı bulunmuştur. Elde edilen bu bulguların nedenleri olarak deney grubu öğrencilerinin daha fazla öğrenen özerkliğine sahip olmaları, ihtiyaç duydukları anda geribildirim alabilmeleri, işbirlikli öğrenme yoluyla öğrenmeleri, etkinliklerin öğrencilerin ilgisini çekecek yapıda ve Gerçekçi Matematik Eğitimi yaklaşımı kullanılarak tasarlanmış olması sayılabilir. İlgili alanyazın incelendiğinde Akış Kuramı ilkelerinin uygulandığı öğretim ortamlarında bahsedilen bu temel unsurların kullanılması sonucunda bu çalışmanın bulgularını destekleyen sonuçlar elde eden çalışmalara rastlamak mümkündür (Admiraal vd., 2011; Annetta, vd., 2009; Bintaş vd., 2003; Can, 2012; Demirdögen, 2007; Freudenthal, 1991; De Lange, 1987; Gravemeijer, 1994; Kirchhoff, 2013).

Öğretimin Akış, Sıkılma ve Motivasyon Üzerindeki Etkisi

Bu çalışmadan elde edilen bulgulara göre, deney grubunda uygulanan öğretim öğrencilerin Akış, Sıkılma ve Motivasyon puanları üzerinde olumlu etkilere neden olmuştur. Deney ve kontrol gruplarının son test Akış alt-boyutu puanları arasında deney grubu lehine anlamlı bir fark vardır. Ayrıca deney grubu öğrencilerinin son test Akış alt-boyutu puanları öntest puanlarına göre anlamlı olarak daha yüksektir. Diğer taraftan, deney grubu öğrencilerinin son test Sıkılma alt-boyutu puanlarının öntest puanlarına göre anlamlı olarak daha düşük olduğu belirlenmiştir. Ayrıca deney grubunun son test motivasyon puanlarının ön test puanlarına göre, kontrol grubundan anlamlı olarak daha yüksek olduğu belirlenmiştir.

İlgili alanyazında bu bulguları hem destekleyen hem de çelişen sonuçlara rastlamak mümkündür (Alperer, 2005; Bourgeois, 2012; Chan ve Ahern, 1999; Engeser ve Rheinberg, 2008; Esteban-Millat, vd., 2014; Heine, 1997; Inal ve Cagiltay, 2007; Latz, 2012; Middleton, 1995; Üzel, 2007; Rogatko, 2009; Santosa, 2015; Schweinle, Turner ve Meyer, 2006; Zheng, 2012). Bu bulguların elde edilmesinin ardında yatan etmenler deney grubunda öğrenci düzeyi ile etkinlik düzeyi arasındaki dengeye dikkat edilmiş olması, öğrenen özerkliğinin ve kontrol hissinin öğrencilere sağlanması, olumlu duyguların teşvik edilmesi, öğrenenler arası ilişki ve etkileşimi sağlayıcı etkinliklerin kullanılması, öğrenenlerin ilgisini çekecek öğretim materyallerinden yararlanılması sayılabilir (Egbert, 2003; Esteban-Millat vd., 2014; Hamari vd., 2016; Heine, 1997; Inal ve Cagiltay, 2007; Huang vd., 2018; Keller ve Bless, 2008; Kiili, Freitas, Arnab ve Lainema, 2012; Kirchhoff, 2013; Rha, Williams ve Heo, 2005; Rheinberg ve Vollmeyer, 2003; Santosa, 2015; Schweinle vd., 2006; Sedighian, 1998; Weiss, 2015).

Öğretimin Kaygı Üzerindeki Etkisi

Araştırmanın sonuçları, deney ve kontrol gruplarının Kaygı alt-boyutu puanları arasında anlamlı bir fark olmadığını göstermiştir. Bu sonucun elde edilmesinde, deneysel işlemde önce de her iki grubunun düşük düzeyde kaygıya sahip olmaları etkili olmuş olabilir. Bazı çalışmalardan elde edilen bulgular bu durumu destekler niteliktedir (Franke ve Bogner, 2013). Kaygı durumu, yüksek zorluk düzeyi ile düşük beceri düzeyinin karşılaşması sonucu ortaya çıkar (Csikszentmihalyi, 1975;

Csikszentmihalyi ve Nakamura, 1989; Whalen, 1997). Egbert (2003) öğrencilerin akışı yaşayabilmeleri için belirli bir düzeyde kaygı ve stresin olması gerektiğini belirtmektedir. Akış Kuramına göre kaygı duygusu, eylemlerin doğru yapıp yapılmadığını düzenleyen bir mekanizma olarak işlev görür. Birey, eylemlerinin kontrolünü hissederse iyi gittiğini fark eder, oysa kaygıya kapılması durumun kötüye gittiğini ve hemen düzeltmeler yapması gerektiğini gösterir. Bireyin etkinlik sırasında aldığı bu geri bildirim döngüsü sayesinde birey becerilerini geliştirme ihtiyacı duyar ve kaygı durumundan çıkarak tekrar akış kanalına girer (Csikszentmihalyi, 1975).

Deney Grubu Öğrencilerinin Öğretim Hakkında Görüşleri Üzerine Tartışma

Tematik analiz sonucunda elde edilen verilere göre, deney grubu öğrencileri kendilerine uygulanan öğretimle ilgili genel olarak olumlu görüşler bildirmişlerdir. Elde edilen veriler, alanyazında Akış Kuramı ve motivasyon ile ilgili yapılan çalışmalardan elde edilen bulgulara paralel olarak, *Özellikler* ve *Etkiler* şeklinde tanımlanan iki ana kategoride incelenmiştir (Miles, 2012; Montanez, 2011; Önce, 2020; Pearce, 2004). Çalışmada, öğrenci görüşleri matematik öğretiminin özellikleri ve öğretimi gerçekleştiren öğretmenin özelliklerini içermektedir. Ayrıca öğrenciler kendilerine uygulanan öğretimin *bilişsel*, *motivasyonel* ve *sosyal* yönden bazı etkileri olduğunu belirtmişlerdir.

Öneriler

Uygulamaya Yönelik Öneriler

1. Akış Kuramı, eğitim araştırmacıları ve matematik öğretmenleri tarafından 5. sınıf matematik öğretimine dahil edilebilir.
2. Öğretmenler öğrencilerin matematik dersine karşı motivasyonlarının olması, derse keyifle katılmaları ve eğlenirken öğrenmeleri için matematik öğretiminde Akış Kuramı ilkelerini kullanmalıdır.
3. Öğrencilere ders sırasında daha fazla kontrol ve özerklik duygusu verilmeli ve öğretmenler öğrenme ortamını kontrol edici değil, yönlendirici rolüne sahip olmalıdır.

4. Öğretmenler, öğrencilerin dersle ilgili her türlü fikirlerini paylaşabilecekleri bir ortam sağlamalıdır. Böylece öğrencilerin yanlış cevapları doğru öğrenmeler için bir fırsata dönüştürülmelidir.
5. Matematik öğretimi mümkün olduğunca öğrenciler arası etkileşimi sağlamalıdır.
6. Matematik dersinde öğrencilerin bilişsel becerileri kadar duyuşsal özelliklerine de dikkat edilmelidir. Sınıfta öğrenciler ve öğretmen-öğrenci etkileşimleri arasında olumlu duygular desteklenmelidir. Derecelendirmeye yönelik değerlendirmelerden ve tehdit algısı içeren ifadelerden kaçınılmalı, öğrenmenin önemli olduğu sıcak ve samimi bir ortam oluşturulmaya çalışılmalıdır.
7. Öğrenciler, ihtiyaç duyduklarında birbirlerinden ve öğretmenden yardım almaya teşvik edilmeli ve cevapları hakkında onlara anında ve bilgilendirici geri bildirim sağlanmalıdır.
8. Öğrenme etkinlikleri, öğrencilerin gelişimsel özellikleri dikkate alınarak öğrencilerin ilgisini çekecek içeriklere sahip olmalı ve çeşitli araç gereçlerin (somut materyal, teknoloji) kullanımını gerektirmelidir.
9. Matematik öğretiminde kullanılan etkinliklerin zorluk düzeyi ile öğrencilerin algıladıkları beceri düzeyi arasında denge sağlanmalıdır.
10. Yukarıda belirtilen bu özellikler, matematik öğretiminde akademik başarı, motivasyon ve diğer olumlu etkileri sağlamak için gerekli ancak yeterli değildir. Bunların sağlanabilmesi için tüm akış özelliklerinin olabildiğince birlikte ve bütünsel olarak kullanılması gerekmektedir.

Gelecekte Yapılacak Olan Çalışmalara Yönelik Öneriler

1. Bu araştırma İzmir ili Bornova ilçesindeki devlet okullarından birinde öğrenim gören 5. sınıf öğrencileri ($n = 73$) ile sınırlıdır. Diğer okul ortamları ve daha büyük örneklemelerle daha fazla deneysel çalışmalar yapılabilir.
2. Akış Kuramına dayalı olarak geliştirilen matematik öğretiminin başarı, kalıcılık, motivasyon ve akış durumu üzerindeki etkilerini araştırmak için gelecekteki

çalışmalar ortaokul kademelerinin diğer sınıfları (6 - 8. sınıflar) ile birlikte tasarlanabilir.

3. Akış Kuramı'nın matematik derslerindeki etkilerini daha detaylı incelemek için daha önceki sınıf düzeylerinden başlayarak boylamsal çalışmalar planlanabilir, deney ve kontrol grupları arasında karşılaştırmalar yapılabilir.

4. Bu çalışmada, MEB tarafından önerilen programda yer alan ve çalışmanın yürütüldüğü haftalarda öğretilmesi planlanan hedefler ve üniteler ele alınmıştır. İleride yapılacak çalışmalarda Akış Kuramının etkileri farklı konu, ünite ve öğrenme çıktılarında incelenebilir.

5. Akış Kuramı, literatürde motivasyon kuramı olarak ele alındığından, öğrencilerin motive olmakta zorlandıkları diğer derslerde (fen, yabancı dil vb.) akademik başarı ve motivasyon üzerindeki etkileri test edilebilir.

6. Literatürde akış durumunun öncülleri ve sonuçları hakkında farklı bulgular vardır. Bu öncüllerin ve sonuçların farklı varyasyonları dikkate alınarak ilişkisel çalışmalar yapılabilir.

7. Bu çalışmada Akış Kuramı'nın ifade ettiği temel boyutlar olan akış, sıkılma ve kaygı ele alınmıştır. Gelecekteki çalışmalarda farklı akış modellerinin (örneğin Massimini ve Carli, 1998) ortaya koyduğu boyutların incelendiği tasarımlar kullanılabilir.

8. Çalışmada kullanılan veri toplama araçlarına ek olarak, aynı zaman diliminde çok sayıda ölçüm gerektiren ve katılımcıların anlık görüşlerini ele alan Deneyim Örnekleme Yöntemi gibi yöntemler kullanılarak gelecekte çalışmalar yapılabilir.

9. Bu çalışmada Akış Kuramı ilkelerinin matematik öğretiminde uygulanması için Gerçekçi Matematik Eğitiminin önerdiği öğretim etkinliği tasarımlarından faydalanılmıştır. İleride yapılacak çalışmalarda farklı öğretim yöntem ve teknikleri (oyun temelli, teknoloji destekli öğretim vb.) Akış Kuramı ilkeleri ile birlikte kullanılarak öğretim tasarımları yapılabilir ve kuramın etkileri incelenebilir.

10. İleride yapılacak çalışmalarda Akış Kuramı ile birlikte diğer motivasyon kuramları (örneğin Öz-Belirleme Kuramı) dikkate alınarak daha kapsamlı öğretim tasarımları

yapılabilir. Bu öğretim tasarımlarının etkililiđi, deneysel alıřmalar yapılarak MEB tarafından önerilen programla karşılaştırılabilir.

11. alıřmadaki gruplar hali hazırda var olan sınıflardan belirlendiđi için alıřmada rastgele atanmanın kullanılması mümkün olmamıştır. Sonraki alıřmalarda deneklerin rastgele atanarak belirlendiđi farklı alıřmalar yapılabilir.

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