INVESTIGATING BELIEFS AND PERCEIVED SELF-EFFICACY BELIEFS OF PROSPECTIVE ELEMENTARY MATHEMATICS TEACHERS TOWARDS USING ORIGAMI IN MATHEMATICS EDUCATION

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ABSTRACT

INVESTIGATING BELIEFS AND PERCEIVED SELF-EFFICACY BELIEFS OF PROSPECTIVE ELEMENTARY MATHEMATICS TEACHERS TOWARDS USING ORIGAMI IN MATHEMATICS EDUCATION

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The purpose of this study is developing valid and reliable scales in order to measure beliefs and perceived self-efficacy beliefs towards using origami in mathematics education and then, investigating beliefs and perceived self-efficacy beliefs of Turkish prospective elementary mathematics teachers in using origami in mathematics education. Furthermore, gender differences in prospective teachers' beliefs and perceived self-efficacy beliefs in using origami in mathematics education were investigated.

Data for the current study was collected in the spring term of 2011-2012 academic year from 299 prospective elementary mathematics teachers. These teacher candidates are from three universities located in three different regions of Turkey and all the participants have elective origami course experience. Origami in Mathematics

Education Belief Scale (OMEBS) and Origami in Mathematics Education Self-Efficacy Scale (OMESS) were used as data collection instruments.

Exploratory and confirmatory factor analysis results showed that OMEBS and OMESS are valid and reliable instruments in order to measure beliefs and perceived self-efficacy beliefs in using origami in mathematics education. Descriptive analysis results indicated that, Turkish prospective elementary mathematics teachers strongly believe that origami is beneficial and suitable to be used in mathematics education. However, their perceived self-efficacy belief level is at little higher than moderate level. Lastly, independent sample t-test results revealed that female teacher candidates have significantly higher belief and perceived self-efficacy beliefs in using origami in mathematics education when compared with male teacher candidates.

Keywords: Origami in Mathematics Education, Beliefs, Perceived Self-Efficacy Beliefs, Prospective Elementary Mathematics Teachers

ÖZ

İLKÖĞRETİM MATEMATİK ÖĞRETMEN ADAYLARININ ORİGAMİNİN MATEMATİK EĞİTİMİNDE KULLANILMASINA YÖNELİK İNANÇ VE ÖZ YETERLİK ALGILARININ İNCELENMESİ

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Bu çalışmanın amacı, origaminin mathematik eğitiminde kullanılmasına yönelik geçerli ve güvenilir inanç ve öz yeterlik algısı ölçekleri geliştirmek ve bu ölçeklerin yardımıyla ilköğretim matematik öğretmen adaylarının origaminin matematik eğitiminde kullanılmasına yönelik inanç ve öz yeterlik algılarını belirlemektir. Ayrıca, öğretmen adaylarının origaminin matematik eğitiminde kullanılmasına yönelik inanç ve öz yeterlik algılarında cinsiyet farlılıkları da incelenmiştir.

Bu çalışma için veriler, 2011-2012 eğitim öğretim yılının bahar döneminde 299 ilköğretim matematik öğretmen adayından toplanmıştır. Bu öğretmen adayları Türkiye'nin üç farklı coğrafi bölgesindeki üç üniversiteden olup, katılımcılarının tümünün seçmeli origami ders tecrübesi bulunmaktadır. Veri toplama aracı olarak Matematik Eğitiminde Origami İnanç Ölçeği ve Origami Temelli Matematik Öğretimi Öz Yeterlik Ölçeği kullanılmıştır.

Açımlayıcı ve doğrulayıcı faktör analiz sonuçları geliştirilen ölçeklerin geçerli ve güvenilir olduğunu göstermiştir. Betimsel istatistik sonuçlarına göre, ilköğretim matematik öğretmen adaylarının origaminin matematik eğitiminde kullanılmasına uygun ve aynı zamanda yararlı olduğuna kuvvetle inandıkları görülmüştür. Bununla birlikte, öz yeterlik algılarının ise orta seviyenin biraz üzerinde olduğu belirlenmiştir. Son olarak, bağımsız örneklemler t-testi sonuçları origaminin matematik eğitiminde kullanılması konusunda kadın öğretmen adaylarının erkek öğretmen adaylarından istatistiksel olarak anlamlı düzeyde daha yüksek inanç ve öz yeterlik algılarına sahip oldukları görülmüştür.

Anahtar Kelimeler: Matematik Eğitiminde Origami, İnançlar, Öz Yeterlik Algıları, İlköğretim Matematik Öğretmen Adayları

To my father and mother
Rüstem & Fatma Birgül ARSLAN

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ABBREVIATIONS

BTS: Bartlett's test of sphericity

CFI: Comparative Fit Index

Df: Degree of freedom

f: Frequency

GFI: Goodness of Fit Index

KMO: Kaiser-Meyer-Olkin Measure of Sampling Adequacy

M: Mean

MoNE: Ministry of National Education

N: Sample size

NC: Normed Chi-Square

NFI: Normed Fit Index

OMEBS: Origami in Mathematics Education Belief Scale

OMESS: Origami in Mathematics Education Self-Efficacy Scale

p: Significance level

RMSEA: Root Mean Square Error of Approximation

SD: Standard Deviation

CHAPTER 1

INTRODUCTION

Origami**,** the Japanese art of paper folding, has become an important research topic in mathematics education (Yoshioka, 1963) since origami possesses great mathematical potential when used in education (Olson, 1989). Origami not only enables students to gain hands on experience in mathematics (Olson, 1989) but it is also enjoyable for both students and teachers (Georgeson, 2011).

In mathematics education, origami is most frequently used in the teaching of geometry since origami entails natural geometric principles in the folding process (Demaine & O'Rourke, 2007). Therefore, origami can be used to promote the geometry knowledge of students (Arıcı, 2012; Boakes, 2008; 2009; Canadas, Molina, Gallardo, Martinez-Santaolla & Penas, 2010; Chen, 2005; DeYoung, 2009; Golan & Jackson, 2010; Johnson, 1999; Sze, 2005b; Tuğrul & Kavici, 2002; Yoshioka, 1963). In addition to geometry, origami can also be used in teaching topics related to algebra (DeYoung, 2009; Higginson & Colgan, 2001; Yoshioka, 1963); fractions (Akan-Sağsöz; 2008; DeYoung, 2009); spatial visualization (Arıcı, 2012; Boakes, 2008; 2009; Çakmak, 2009) and linear measurement (DeYoung; 2009; Tuğrul & Kavici, 2002). It is possible to extend the mathematical topics in which origami can be used but the common point in these topics is that origami functions as a bridge between the abstract nature of mathematics and the concrete world of the paper folding process (Georgeson, 2011; Wares, 2011). In addition to the beneficial uses of origami in specific topics in mathematics, it is also of benefit in improving general mathematical abilities such as mathematical problem solving ability (Robichaux & Rodrigue, 2003) and creativity (Purnell, 2009).

Origami has started to take its place in the national mathematics curriculum with the reform movements that started in 2003. Ministry of National Education (MoNE, 2009b) defines origami as an instruction method which has various mathematical benefits for students, such as making some abstract mathematical concepts more concrete, gaining geometry knowledge and improving mathematical language. Therefore, different origami activities for various grades have been integrated into the national mathematics curriculum. These activities are mostly related to geometry topics and the number of these activities is much higher in the elementary mathematics curriculum when compared with the upper elementary and secondary mathematics curricula.

In accordance with the changes in the national mathematics curriculum, some universities began to offer to prospective mathematics teachers elective courses on origami based mathematics instruction. The main purpose of these courses is to introduce origami as a mathematics teaching method and to show the possible outcomes when used in mathematics lessons. Although some differences appear in the programs of these courses, courses are generally based on classroom activities which enable students to see various mathematical effects of origami and on introducing how to effectively use origami as a mathematics teaching method in order to enable prospective teachers to gain efficacy in using origami in mathematics lessons.

Although there are studies on why and how to use origami in mathematics education (e.g., Boakes, 2008; Cornelius & Tubis, 2009; Higginson & Colgan, 2001; Patry, 2010; Sze, 2005b; Tuğrul & Kavici, 2002), there are few studies on the treatment effects of origami when used in mathematics lessons (e.g., Boakes, 2009; Çakmak; 2009; Yuzawa & Bart, 2002). Apart from cognitive aspects, in the origami related accessible literature no studies about affective issues were reached. However, affective issues have an important place in mathematics education (McLeod, 1994) since teachers' ways of thinking and understanding have an impact on their teaching performance in the classroom (Nespor, 1987). There is a wide range of affective issues but in the current study the main focus is on beliefs, specifically perceived self-efficacy beliefs. When the issue is beliefs and self-efficacy beliefs, research studies on prospective teachers are crucial since determining their beliefs helps to predict their future teaching behaviors (Pajares, 1992). Moreover these research studies help to interpret the effectiveness of teacher education programs whether outcomes are consistent with the purposes of program (Kagan, 1992). Investigating gender differences is also beneficial since gender is regarded as an important factor on beliefs (Li, 1999).

Although beliefs of prospective teachers have been investigated in the literature, there is no research study found in the accessible origami literature in terms of beliefs of prospective teachers. Therefore, it is possible to say that the number of instruments measuring beliefs and self-efficacy beliefs of prospective teachers in using origami in mathematics education are very limited. For this reason, the first aim of the present study is to develop a valid and reliable scale to measure prospective mathematics teachers' beliefs and perceived self-efficacy beliefs in using origami as a teaching tool in mathematics education. Revealing these beliefs and self-efficacy beliefs and gender differences in these beliefs are expected to be beneficial in anticipating prospective teachers' possible future decisions in using origami in mathematics education and the results of the study may help to shape current origami courses in universities. Moreover, developing valid and reliable scales to measure beliefs and self-efficacy beliefs towards using origami in mathematics lessons can enable researchers to use these scales for further research.

1.1. Purpose of the Study

The first purpose of the study is to develop a valid and reliable scale in order to measure beliefs and perceived self-efficacy beliefs towards using origami in mathematics education. Another purpose of the study is to investigate prospective teachers' beliefs and perceived self-efficacy beliefs towards using origami in mathematics education. Finally, the current study aims to identify whether these beliefs and perceived self-efficacy beliefs differ by gender.

1.2. Research Questions

In accordance with the purpose of the study the following research questions and hypotheses are investigated in the current study:

1. Is the Origami in Mathematics Education Belief Scale valid and reliable?

2. Is the Origami in Mathematics Education Self-Efficacy Scale valid and reliable?

3. What are the beliefs of prospective elementary mathematics teachers towards using origami in mathematics education?

4. Is there a statistically significant mean difference between female and male prospective elementary mathematics teachers’ beliefs towards using origami in mathematics education?

H_0: There is no statistically significant mean difference between female and male prospective elementary mathematics teachers' beliefs towards using origami in mathematics education.

5. What are the prospective mathematics teachers' perceived self-efficacy belief levels in using origami in mathematics education?

6. Is there a statistically significant mean difference between female and male prospective elementary mathematics teachers’ perceived self-efficacy belief levels in using origami in mathematics education?

H_0: There is no statistically significant mean difference between female and male prospective elementary mathematics teachers’ perceived self-efficacy belief levels in using origami in mathematics education.

1.3. Definition of Important Terms

The operational and constitutive definitions of important terms are presented below to gain a more profound insight into the research questions.

Origami is defined as “the Japanese art of folding paper into decorative shapes and figures” (Oxford Dictionaries, 2012).

Beliefs are “psychologically held understandings, premises, or propositions about the world that are felt to be true” (Richardson, 1996, p. 103). In the current study beliefs in using origami in mathematics education refers to prospective teachers' opinions which felt to be true about origami when it is used in mathematics lessons and measured via Origami in Mathematics Education Belief Scale (OMEBS).

Efficacy is “the ability to produce a desired or intended result” (Oxford Dictionaries, 2012). *Perceived self-efficacy beliefs* as defined by Bandura (1997) refer to “beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (p.3). In this study perceived self-efficacy belief levels in using origami in mathematics education refers to beliefs about how well teacher candidates can use origami as a teaching tool in mathematics lessons and measured via Origami in Mathematics Education Self-Efficacy Scale.

Finally, *prospective mathematics teachers* are students in elementary mathematics education department who will become mathematics teachers in elementary schools (4^{th}-8^{th} grades) after graduation.

1.4. Significance of the Study

Although there is an agreement on the usage of origami in mathematics education for different mathematical aims, studies that investigate its treatment effects in mathematics lessons are limited (Boakes, 2008). Existing research studies mostly focus on how origami can be effectively used in mathematics lessons and experiences gained in origami based mathematics lessons (e.g., Georgeson, 2011; Golan & Jackson, 2010; Higginson & Colgan, 2001; Purnell, 2009; Wares, 2011).

However, limited research studies on the treatment effects of origami based mathematics instruction generally revealed significant results in favor of origami mathematics lessons (e.g., Akan-Sağsöz, 2008; Boakes, 2009; Çakmak, 2009; Yuzawa & Bart, 2002). These promising results have also affected the national curriculum, and origami has begun to take place not only in elementary and secondary schools' mathematics curriculum but also education faculties' program. Although, some universities have begun to offer elective courses on origami mathematics lessons in order to introduce origami mathematics lessons to prospective mathematics teachers, no research study could be encountered in the accessible literature conducted on prospective teachers. However, as stated above research studies on prospective teachers' beliefs are of great importance since their decisions regarding the use of origami in their mathematics instruction can be predicted (Benken & Wilson, 1998) as there is a common conception in related literature that beliefs act as filters and affect teaching decisions (Thompson, 1992). Therefore, it is expected that investigating prospective teachers' beliefs towards using origami in mathematics education will give an overall view of their future decisions on using origami as a teaching tool. Furthermore, it will be possible to see at what degree prospective teachers believe that origami can be used in mathematics lessons.

In addition to investigating prospective teachers' beliefs regarding origami mathematics lessons, it is also crucial to investigate their self-efficacy beliefs regarding this issue. The reason derives from the fact that, origami based lessons have a unique lesson structure and thus, some teacher requirements are essential for effective instruction (Golan & Jackson, 2010). Do prospective teachers in Turkey feel confident to use origami in mathematics lessons? There are elective courses for prospective teachers in order to gain knowledge and confidence in origami based mathematics lessons but to what extent teacher candidates feel confident in using origami in mathematics education has not been studied in the accessible literature. Therefore, it is believed that investigating prospective teachers' beliefs will provide valuable information for both origami related literature and universities which have elementary mathematics education programs.

From the aspect of affective factors in mathematics education, gender arises as an important factor to be studied (Yazıcı & Ertekin, 2010) since there is a need for further research in order to determine effects of gender in mathematics education (Fennema, 2002). Therefore, investigating whether beliefs and perceived self-efficacy beliefs of prospective teachers in using origami in mathematics education differ by gender can be of benefit to understand their perspectives in using origami in mathematics lessons. Researches in related literature showed that, female teachers tend to use more activity based approaches (Li, 1999) and origami is generally accepted as a teaching method in which students actively participate in the learning process (Sze, 2005a). Therefore, investigating gender differences in prospective teachers' beliefs and perceived self-efficacy beliefs regarding using origami in mathematics education can shed light on the possible differences in teacher candidates' interpretations regarding origami as a teaching method.

To sum up, it is expected that the current study will help to improve origami related mathematics education literature since the number of studies on origami in terms of affective factors is insufficient in the accessible literature. Furthermore, valid and reliable scales measuring beliefs and perceived self-efficacy beliefs in using origami in mathematics education were developed. These scales can be used in other research studies with different samples to gain deeper insight into prospective teachers' beliefs and perceived self-efficacy beliefs regarding the use of origami in mathematics education. Moreover, investigating gender differences in prospective teachers' origami related beliefs and perceived self-efficacy beliefs can shed light on whether there is a difference between female and male teacher candidates' tendency to use origami in mathematics lessons.

1.5. My Motivation for the Study

My origami adventure began in the first year of my university education by watching an origami tulip from a video. Then, I continued to learn new origami models from origami books and videos from websites. In later years, every piece of paper became a potential material to be folded into origami figures for me. At first, it was just an amusing activity which was a source of relaxation. However, afterwards, I realized its connection with mathematics during the folding steps and started to investigate whether it could be used in mathematics education. My investigations surprised me when I saw the potential of origami in mathematics. At first, it seemed that folding steps could be used only in topics related to geometry but after reading articles and books on this issue I realized the potential of origami in almost every topic of mathematics such as fractions, rate, ratio etc. So, in every origami model folded, I started to think about its relationship with the mathematics topics and after finishing the model I unfolded the model in order to see the crease pattern. After getting involved in the world of origami mathematics, I realized the elective origami courses for prospective teachers in some universities and became curious about teacher candidates' beliefs regarding the use of origami in mathematics lessons. Therefore, I decided to focus on this issue in my master thesis in order to conduct a study on a topic which I enjoyed so much.

CHAPTER 2

REVIEW OF LITERATURE

The purpose of the current study is to initially develop a valid and reliable instrument to measure prospective teachers' origami related beliefs and perceived self-efficacy beliefs and then, to investigate prospective mathematics teachers' beliefs and perceived self-efficacy beliefs towards using origami in mathematics education through the use of this scale. Furthermore, this study also aimed to investigate gender differences in beliefs and perceived self-efficacy beliefs of prospective elementary mathematics teachers towards using origami in mathematics education.

In light of these research objectives, this chapter represents the broad review of the literature on origami, beliefs and self-efficacy beliefs, and consists of two main parts, namely origami and affective factors. The first part, origami is investigated under seven subheadings which are why origami can be used in education, origami in learning theories, origami in mathematics education, research studies on origami based mathematics instruction, origami in national curriculum context, origami in national research studies and finally how to use origami effectively in mathematics classrooms. The second part, affective factors, is specifically based on beliefs and perceived self-efficacy beliefs, the significance of studying these beliefs in mathematics education and related studies. Furthermore, in the second part one subsection is dedicated to studies that investigate gender differences in mathematics education. Finally, a brief summary of related literature which shapes the current study is presented.

2.1. What is Origami?

Origami is the combination of two Japanese words "ori", which means *to fold* and "kami" which means *paper* (Beech, 2009; Franco, 1999; Yoshioka, 1963). The word "kami" also means *god* in Japanese, which may lead the Japanese to attribute a deeper meaning to origami (Franco, 2009). In general, origami is known as the art of paper folding.

There is no accurate knowledge about the origin of origami but it is believed to be founded in China and then brought to Japan, where the real evolution of origami has occurred for more than 1200 years ago, and much later, origami was taken to Spain, the first country in the West, with the effect of "Silk Road" (Tuğrul & Kavici, 2002). Although origami is a very old art, in the last 50 years new folding techniques have been invented and origami has shown great progression (Beech, 2009; Lang, 2009). Now, origami is loved all around the world by people who can communicate with the language of origami (Franco, 1999).

In traditional origami one sheet of paper is used to make an animal, a flower, etc. by folding the paper. Generally a square shaped paper is used but there are also origami models which can be folded by using a rectangular shaped paper. In contrast to traditional origami, more than one sheet of paper is used in "Modular Origami". Mitchell (2005) described modular origami in detail by stating that each sheet of paper is folded in the same way to make up a module of the polyhedral model.

Modular origami was originated in the U.S.A. in the beginning of the 1960s (Mitchell, 2005) and is also known as "Unit Origami" (Georgeson, 2011). With modular origami it is possible to fold different types of polyhedral models and decorative shapes (Franco, 1999).

Although the art of paper folding, origami, has not originated as an educational instrument, it became an important tool to be used in education in subsequent years. Thus, the next section is dedicated to explain which characteristics make origami important for its utilization in education.

2.1.1. Why Origami can be used in Education

At first, origami can be seen as a hobby in which animals, flowers and good looking figures are constructed from paper. However, origami is more than this; it has cognitive, emotional, and motoric aspects (Golan & Jackson, 2010). Origami can address different intelligences since it is a verbal activity whereby instructions are listened to, it is a visual activity since there is a model to visualize and it is also a physical activity in which both hands are used (Boakes, 2009; Sze, 2005a; Tuğrul & Kavici, 2002). Therefore, in the process of the origami activity, the origami maker needs to be visually, audibly, and kinesthetically active, which are also essential for effective learning (Tuğrul & Kavici, 2002). These developmental and educational effects make it important to use origami in education (MoNE, 2009a). Therefore, developmental and educational potentials of origami will be explained in detail in order to clarify why origami can be used in education.

Origami can be used to improve psychomotor skills especially for primary school students (Golan & Jackson, 2010; Tuğrul & Kavici, 2002). During the folding process, fine motor skills are used (Tuğrul & Kavici, 2002) which in turn, improves hand-eye coordination (Golan & Jackson, 2010). Furthermore, Shumakova and Shumakov (2000) stated that, origami enables using both left and right brain hemispheres since when folding an origami model both hands should be used. Therefore, researchers suggest using origami in schools especially for young students to be able to improve their psychomotor skills since it is an important aim for that level of education.

In addition to the physical and cognitive effects of origami, it has also affective aspects (Golan & Jackson, 2010). In the process of origami, one needs to decide on the origami model, the color of the paper and fold the model by oneself, which helps to improve self-confidence (Tuğrul & Kavici, 2002). Furthermore, origami based lessons are highly motivating activities for students (Georgeson, 2011).

Physical, cognitive and affective aspects of origami enable it to be used in accordance with different learning theories. Therefore, the suitability of origami with respect to different learning theories is explained in the next section.

2.1.2. Origami in Learning Theories

Origami can be used as an instruction method in accordance with different learning models. Piaget stated that children should be active in the process of learning and it is an appropriate activity for Piagetian Theory since origami activities give the chance to students to be able to construct the knowledge on their own (Boakes, 2009). In the study of Tuğrul and Kavici (2002), characteristics of origami were investigated to evaluate its appropriateness with respect to different learning models. Origami has similar characteristics from the perspective of the active learning model since students must be active in the process of folding and work alone by implementing origami diagrams. In especially modular origami, students are required to do several units to construct the main model. Therefore, working in groups makes it easier to fold modular origami models and also, in the process, students share their knowledge with each other. These characteristics show that origami can be a useful instructional method in cooperative learning model. Furthermore, Tuğrul and Kavici (2002) stated that students can use their creativity to construct different origami models and see the models from different perspectives. Thus, it can be said that origami enhances creativity and may be used in lessons prepared in consistency with the creative learning model. Moreover, it is stated in literature that projects like folding cranes for peace can be organized in schools as both educational and social projects. Therefore, origami can also be used as a tool in the project based learning model. Researchers also stated that origami can be an appropriate tool for brain based learning since it enables using both the right the left brain hemispheres and, thus, enables using different channels in the brain for meaningful learning. In summary, Tuğrul and Kavici (2002) mentioned that origami can be used in education in accordance with different contemporary learning models.

In another study, Sze (2005a) described the common characteristics between origami and the constructivist learning theory. Hands on learning, explicit instruction, higher order thinking, multimodal instruction, social learning and self-management strategies were described as major characteristics of constructivism, and origami is also claimed to have all these characteristics. Therefore, it is concluded that origami based activities can be used in constructivist learning environments, which makes this study important since the new national education program in Turkey is based on the constructivist learning theory.

Research studies in related literature show that origami not only has various educational benefits but can also be used in accordance with different learning theories. Although there are various fields in education in which origami can be used, the most prominent area in which origami can be made use of is mathematics education. Therefore, the issues of why and how to use origami in mathematics education will be explained in detail in the following sections.

2.1.3. Origami in Mathematics Education

It is widely accepted that the art of paper folding has enormous mathematical potential (Higginson & Colgan, 2001). When origami is used in mathematics education, it enables students to understand abstract mathematical topics in a concrete way (Georgeson, 2011). Furthermore, origami activities give students the opportunity to be totally active in the process of learning, which is one of the most important principles in mathematics education (Olson, 1989). In addition to the mathematical potential of origami, the material of origami, paper, is easily reachable and cheap for students, which can also be interpreted as one of the reasons why origami can be used all over the world in mathematics education (Cagle, 2009).

Origami is a widely used instructional tool in mathematics education (Boakes, 2009) and research studies related to this topic go back to more than a hundred years ago (Pope & Lam, 2009). Despite the fact that topic of origami in mathematics education is old, it is possible to say that this topic has drawn much more attention in recent years. In related literature, origami is reported as being ‘beneficial’ for different topics in mathematics education. However, the most known application of origami in mathematics education is topics in geometry. It is possible to construct three dimensional geometric figures in origami, which allows students to gain geometry knowledge in this process (Cagle, 2009). Students not only gain knowledge in geometry during the folding process, but they also acquire geometric insights when they unfold the paper (Georgeson, 2011). By unfolding the paper, the crease pattern of the folded paper appears and this crease pattern can be used for different topics in geometry. It is possible to use these crease patterns in teaching various topics, such as polygons, properties of polygons, angles, parallelism, symmetry, similarity, equality of sides and angles (Canadas, Molina, Gallardo, Martinez-Santaolla & Penas, 2010; Cornelius & Tubis, 2009; Frigerio, 2009; Yoshioka, 1963). Folding and unfolding exercises in geometry also allow students to improve their spatial reasoning skill, which is accepted as a very important skill in mathematics education (Boakes, 2009; Golan & Jackson, 2010).

Various benefits of origami in geometry education had an impact on the national geometry curriculum of some countries. For instance, the program of Origametria, which is the combination of words *origami* and *geometry*, has been applied in Israel in 70 schools since 2002 (Golan & Jackson, 2010). The main aim of the program is using origami to enhance elementary school students' knowledge in geometry. In every geometry lesson, the topic in focus is matched with an origami model and the lesson plan is prepared accordingly. Although Origametria is used particularly for elementary school geometry curriculum, it is planned to be expanded to the high school geometry curriculum as well. The creators of Origametria stated that origami is a powerful way to teach geometric concepts and students love this program. When one school decided to give up the Origametria program because of economic reasons, students demonstrated against this act, which is a powerful example depicting students' opinions regarding origami based geometry (Golan & Jackson, 2010).

Although origami is a powerful way to teach geometry, the place of origami in mathematics education is not restricted with geometry topics. Origami can also be used for teaching fractions (Akan-Sağsöz, 2008; Canadas et al., 2010; Coad, 2006; DeYoung, 2009; Pagni, 2007). With the help of the crease pattern of an origami model, lessons in which proportional reasoning is utilized can be planned, leading to mathematics lessons on fractions (Canadas et al., 2010; DeYoung, 2009). Furthermore, origami can be used in a variety of ways to teach algebra (Cornelius & Tubis, 2009; DeYoung, 2009; Franco, 1999; Georgeson, 2011; Higginson & Colgan, 2001; Olson, 1989; Yoshioka, 1963). For instance, it is possible to prepare an activity to show the expansion of algebraic equation (a+b) squared through paper folding activities and by doing so; students will be totally active while gaining algebraic knowledge (Yoshioka, 1963). In addition to the benefits of origami in various mathematics topics, origami is also highly beneficial in improving the use of mathematical language since origami encourages the use of mathematical terms during the folding process (Cagle, 2009; Cipoletti & Wilson, 2004; Hartzler, 2003; Mastin, 2007; Robichaux & Rodrigue, 2003; Tuğrul & Kavici, 2002).

Origami is not only appropriate for different mathematic topics, but also suitable to be used in different grade levels (Frigerio, 2009; Golan & Jackson, 2009; Olson, 1989). Origami can be used effectively to engage meaningful learning in various mathematics topics in elementary school (Golan & Jackson, 2009; Mastin, 2007; Purnell, 2009), in middle school (Boakes, 2008; DeYoung, 2009; Higginson & Colgan, 2001), and also in high school (Cagle, 2009; Canadas et al., 2010; Cornelius & Tubis, 2009). For instance, an origami box has been studied from different aspects in the literature. The folding process of an origami box can be used in elementary mathematics education to teach polygons, angles, bisections, symmetries (Cornelius & Tubis, 2009). Furthermore, in the higher grades, for example in middle school, origami box can be used in more complex mathematics topics. For instance, algebraic relationship between the size of the origami paper and the volume of the box can be used in algebra teaching (DeYoung, 2009). Moreover, if students use beans to calculate the volume of boxes, they can gain "nonstandard unit knowledge" (Georgeson, 2011), and the relationship between the volume and the size of the origami paper can be graphed to gain graphing knowledge (DeYoung, 2009; Georgeson, 2011). The numerous origami boxes produced in class can be used to construct "Sierpinski's Carpet", which can be utilized to show an example of fractal (Georgeson, 2011). It is difficult to think that the origami box can be used to teach trigonometry in high school. However, in the study of Cornelius and Tubis (2009) there is a good example to see how a triangle origami box can be used in trigonometry. The origami box was also studied by Wares (2011) to show how an origami box can be constructed with the maximum surface area and volume. Wares (2011) mentioned that it can be used in college years for calculus lessons. Although the folding process of an origami box is simple, its applications in mathematics education are rich.

To sum up, researchers agree that it is possible to use origami in mathematics education for various mathematical topics and grade levels, which could make it a powerful instructional tool in mathematics education. For this reason, effects of origami when used as a teaching method in mathematics education have been investigated in related literature. In the following sections, these studies will be explained in detail.

2.1.4. Research Studies on Origami Based Mathematics Instruction

Numerous papers and books on the importance of origami in mathematics education and how it can be used in mathematics lessons have been published (e.g., Auckly & Cleveland, 1995; Boakes, 2008; Chen, 2005; Franco, 1999; Georgeson, 2011; Hull, 2006; Olson, 1989). However, research studies which investigate the treatment effects of origami exercises when used in mathematics education are very limited in number.

In one of these research studies, Yuzawa and Bart (2002) investigated the effect of origami activities on children's size comparison strategies. In this study, twenty four 5-6 year-old children have been selected as the sample from a

Midwestern elementary school in the United States. Children in the control group were assigned origami activities in addition to size comparison tasks while others were assigned only size comparison tasks for five days. For the size comparison tasks seven pairs of triangles, such as congruent pairs, symmetrical pairs, pairs with unequal bases but equal heights were used. According to the results, it was found that the main effect of condition was significant in favor of the experimental group. Therefore, it was concluded that origami exercises increased the number of correct responses the children gave during the five days. Furthermore, researchers investigated the effect of origami exercises on children’s size comparison strategies. Results were found to be significant for one-on-another placement strategy and significant for general-shape adjustment strategy. Therefore, researchers concluded that origami exercises implemented in the experimental group increased the usage of the one-on-another placement strategy and the general-shape adjustment strategy.

In another study, Boakes (2009) investigated the effect of origami-blended lessons on spatial visualization skills and geometry knowledge of middle school students and whether these effects differed by gender. In the study, convenience sampling method was used, and the sample group consisted of 56 students from seventh grade. The study was based on a quasi-experimental pre-test post-test design. During the study, the control group received lessons three days a week, with each daily lesson lasting 80 minutes during the one month geometry unit via the traditional method; while the experimental group received origami based instruction along with the traditional instruction. To measure students' geometry knowledge, a subset of 27 multiple-choice questions from the geometry/spatial sense strand written for eighth-grade students and released by the National Assessment of Educational Progress (NAEP) was used. Students' spatial visualization skills were measured via the Paper Folding Test, the Card Rotation Test, and the Surface Development test. According to the ANCOVA results, no significant differences between the groups were found. Arriving at the conclusion that limited time might have affected the results, the researcher recommended longer investigations.

Although origami has been drawing increasing attention in the literature because of its possible benefits in mathematics education, there are not enough research studies that investigate these possible benefits. Similarly, origami has begun to attract attention in the national curriculum in recent years, but research studies on origami based mathematics instruction are limited. In the following section, how origami appears in the national curriculum and related national studies will be explained in detail.

2.1.5. Origami in the National Curriculum Context

With the impact of the curriculum reform in Turkey, origami began to take place in the new education program. In the elementary mathematics curriculum, MoNE (2009a) mentioned that origami can be used in mathematics education for different purposes, such as using origami as a mathematical game or using it in mathematics history. In accordance with the explanations in the elementary curricula, origami activities were prepared for students from 1st to 5th grades. In these activities, origami was defined as an activity which enables students to improve their creativity, psychomotor ability and spatial thinking ability. Furthermore, it was stated that origami would be of benefit in increasing students’ motivation towards mathematics lessons and, it would enable students to understand the abstract structure of mathematics using concrete models. By means of these activities, it was aimed to teach geometrical shapes, some of the mathematical concepts, and symmetry while also having fun. Moreover, as a teaching tool, origami had an important place in middle school mathematics curriculum. MoNE (2009b) states that origami can be used for enhancing students' problem solving skills, improving two and three dimensional thinking, understanding abstract facts in mathematics, understanding geometrical shapes. It is also highlighted that origami activities can be used in teaching some mathematical concepts, such as rate, ratio etc. Furthermore, in the national middle school program there is a sample lesson activity based on origami for seventh grade students. This activity involves kite making by using origami. Kite making is an example of modular origami, in which more than one sheet of paper is folded. According to MoNE (2009b) through this activity, students will be able to learn properties of diagonals, angles and edges of quadrangles; moreover, students will be able to enhance skills, such as communication and logical thinking, and relate mathematical concepts to each other, which are essential aims of mathematics education. In addition to the elementary and middle school mathematics curriculum, origami has a place in high school geometry curriculum. In the high school geometry curriculum, origami is defined as a valuable instructional tool (MoNE, 2011). In accordance with this definition of origami, there are activities for high school students. In one of them, a rectangular paper is divided into three congruent pieces through paper folding techniques. Furthermore, it is proved mathematically that these three pieces are congruent. Therefore, we can conclude that these kinds of origami activities can be used to teach geometrical concepts; moreover, these activities may lead to different mathematical outcomes, such as the sample activity mentioned.

As can be seen in the mathematics curriculum of Turkey, origami is seen as an important instructional tool in mathematics education from the 1^{st} to the 12^{th} grade. The potential of origami in mathematics education and its importance in the national curriculum have also been influential in some universities' curricula. In six universities that have an elementary mathematics education department, elective courses on origami based mathematics instruction have started to be offered. Although the names of the courses show variety, like origami, modular origami, and mathematics with paper folding, the main purpose of these lessons is to train prospective mathematics teachers in how to use origami in mathematics education.

2.1.6. Origami in National Research Studies

Owing to its possible benefits, origami took an important place in mathematics education for almost all levels in national curriculum, but there is limited research study on the treatment effects of origami based instruction in mathematics education in Turkey.

Kavici (2005) investigated the effect of origami on 5-6 year children's visual perception, mathematical abilities and fine motor skills. For that purpose, a sample of 36 children between 5-6 years of age from a private school in Ankara was selected. The research was based on a pre-test post-test experimental research design in which there was an experimental and a control group. Children in the experimental group was engaged in one hour of origami activity each week for 11 weeks in addition to the traditional education, while the control group only had traditional education. In accordance with the purposes of the study, pretests were applied to both groups before the beginning of instruction. The Fine Motor Skills part of Peabody Developmental Motor Scale (PDMS–2), the Frostig Developmental Test of Visual Perception, and the Mathematical Abilities Check List were used as pre-test instruments. Although there was no significant difference between the two groups in the pre-test, a significant difference was found in the post-tests. According to the results of the post-tests, it was found that children in the experimental group, who were provided with origami activities for 11 weeks, had significantly higher scores than the children in the control group. Therefore, the researcher concluded that origami activities would be beneficial for both physical and mathematical development of students when used during preschool years.

In another study, Çakmak (2009) investigated the effect of origami based instruction on elementary students' spatial ability in mathematics. Purposive sampling was used in this study; class size and the availability of additional mathematics hours were taken into consideration while forming the sample group, which consisted of 15 fourth graders, 9 from fifth grade and 14 sixth grade students from a private school in Ankara. Intervention in all three grade levels lasted for 10 weeks. A pre-test and post-test research design was implemented in the study. Origami based instruction was implemented for ten weeks in all three groups to learn geometrical shapes and specifications. According to the results gained from the Spatial Ability Test, it was found that origami based instruction had a significant effect on elementary students' spatial ability; eta squared statistics was calculated as 0.10. Although Boakes (2009) and Çakmak (2009) investigated similar research questions, they obtained different results. A possible reason for the variation in the results, as stated by Boakes (2009), was the limited time devoted to origami blended lessons. In the study of Çakmak (2009), in addition to quantitative analysis, qualitative data were collected by means of reflection papers and face to face meetings in order to understand students' attitudes. It was found that 37 of the total 38 students had gained positive attitudes towards origami based instruction. In the reflection papers, most of the students described origami as being an enjoyable activity.

In another research, Akan-Sağsöz (2008) studied the effect of origami on teaching fractions to sixth grades. The participants of her study were 80 students from a convenient school in Erzurum; the number of students in the control and experimental groups was equal. The control group attended lessons in which the traditional method based on the textbook was implemented, while the experimental group had lessons based on origami activities in addition to traditional instruction. The study was based on a pre-test and post-test experimental research design with a control group; the pre-test results showed that there was no significant difference between the groups. The post-test results related to knowledge on fractions revealed that students in the experimental group performed significantly better than the students in the control group, particularly in questions based on operations of fractions. Therefore, Akan-Sağsöz (2008) concluded that origami based instruction has a significant effect on teaching fractions.

As can be seen from the studies conducted in Turkey, origami was studied mostly through experimental research designs, and the results of these studies revealed that students gained some cognitive insights during origami based mathematics lessons. However, it should be noted that these studies are limited in number.

2.1.7. How to Use Origami Effectively in Mathematics Classrooms

"Paper folding is fun but where is the math?" (Georgeson, 2011, p.354). If the teacher does not build a connection between origami and mathematics, using origami in mathematics education would be nothing more than an enjoyable activity for students (Georgeson, 2011). To build the connection between origami and mathematics, the teacher needs to be prepared for such kind of an instruction (Cipoletti & Wilson, 2004). Therefore, teachers need to know how to proceed in utilizing origami in mathematics education.

Studies in related literature show that origami can be beneficial in mathematics education if it is used in a right way. There are some suggestions in literature related to the effective use of origami. More specifically, it is stated in literature that to use origami successfully in mathematics lessons, teacher should initially select the topic in which origami will be used (Boakes, 2008; Cornelius & Tubis, 2009; Golan & Jackson, 2010). Then, the appropriate origami model should be selected according to the characteristics of the selected topic (Boakes, 2008; Golan & Jackson, 2010). When deciding on the origami model, students' ability and age should be considered (Cipoletti & Wilson, 2004). After deciding on the model, the steps in the folding process should be defined in relation to the selected mathematics topic (Cipoletti & Wilson, 2004; Cornelius & Tubis, 2009). Before implementing the origami activity in class, teachers should fold the origami model him/herself and anticipate the type of questions that may arise in class during the implementation of the activity (Boakes, 2008; Sze, 2005b). Furthermore, everyday language in origami diagrams should be replaced with mathematical language; for example, the instruction, 'fold along the horizontal line of symmetry' can be used instead of 'fold in half' (Cipoletti & Wilson, 2004). This step is important in order to improve students' use of mathematical language. Replacing everyday language with mathematical language is also believed to make the comprehension of mathematical concepts easier (Cipoletti & Wilson, 2004). Subsequent to the process of teacher preparation, there are also some tips for teachers to do during the activity in the classroom. During the implementation, teachers should assist students by folding the origami model with a bigger sheet of paper in front of the class in addition to the origami diagrams. However, teachers should not interfere with or check the accuracy of students' origami model in order to improve their self-confidence (Golan & Jackson, 2010). Furthermore, teachers should pose topic-related questions to students during the activity. For instance, asking questions, such as 'In how many ways can you fold paper in half?' can provide deep mathematical argumentation process (Cagle, 2009). In addition, teachers should support mathematical discussions through these kinds of questions (Cipoletti & Wilson, 2004). Moreover, grouping students may be beneficial during these mathematical discussions and provide them with the opportunity to assist each other during the origami based mathematics activity (Sze, 2005a). After the activity, summarizing the lesson would be beneficial (Boakes, 2008). Furthermore, teachers need to conduct assessment activities in order to measure whether students understand mathematical vocabulary and concepts during the activity (Cipoletti & Wilson, 2004).

Knowledge on what to do in origami based mathematics instruction is crucial to implement an effective origami based mathematics lesson. Furthermore, beliefs of instructors shape future classroom behaviors (Pajares, 1992); hence, in addition to instructors' knowledge on this issue, their beliefs about the method of instruction are highly important for effective teaching. Therefore, the following section is dedicated to studies related to beliefs in mathematics education.

2.2. The Issue of Beliefs: Definition of Belief and to the Significance of Studying Beliefs in Mathematics Education

The number of research studies investigating beliefs in mathematics education literature has increased (Philipp, 2007) since these studies possess great educational benefits (Pajares, 1992). Although, there are increasing studies on beliefs, there is no common definition of belief in the literature (Pajares, 1992; Philipp, 2007). Therefore, it is possible to encounter various definitions of *belief* in the literature. For instance, Goldin (2002) defined belief as "Multiply encoded cognitive/affective configurations, to which the holder attributes some kind of truth value" (p.59) and Kagan (1992) defined *teacher belief* as "Tacit, often unconsciously held assumptions about students, classrooms, and the academic material to be taught" (p.65). Although there are various definitions for the term *belief*, in the current study

Richardson’ (1996) definition of the term *belief* was used as: “Psychologically held understandings, premises, or propositions about the world that are thought to be true" (p.103). Beliefs are based on past experiences (Hart, 2002; Pajares, 1992) and are generally stable over time (Kagan, 1992). Furthermore, beliefs develop over a long time (Emenaker, 1995) and it is not possible to have a consensus on specific beliefs since it depends on personal judgments (Philipp, 2007).

Although, there is no generally accepted definition of belief, researchers in the literature arrive at a common point regarding the effects of beliefs on behavior. In the literature the commonly accepted idea is that beliefs shape future decisions and behaviors (Kagan, 1992; Li, 1999; Nespor, 1987; Pajares, 1992; Thompson, 1984; 1992). Therefore, studies which focus on beliefs of teachers and teacher candidates will give valuable information about educational issues (Pajares, 1992). Determining beliefs of teachers and prospective teachers would be beneficial not only in predicting their teaching behavior, but also in organizing college and in-service programs for effective teaching (Kagan, 1992; Pajares, 1992).

When the issue is prospective teachers’ beliefs, it should be stated that there is a wide range of research studies on this issue. For instance, prospective teachers’ beliefs about the nature of mathematics, math teaching, specific teaching method, and students’ mathematical thinking have been investigated in the literature. Among this wide range, the current study focused on prospective teachers’ beliefs about a specific teaching method in mathematics education: origami based mathematics instruction. Prospective teachers’ judgment in using origami in mathematics education was investigated in order to understand their beliefs in benefits and limitations of origami as a teaching tool. Determining these beliefs would be beneficial to shape the current curriculum as stated by Pajares (1992).

In addition to beliefs, research on specific types of beliefs, such as self-efficacy, is important in education (Pajares, 1992) since these beliefs affect future decisions and effort on behavior (Bandura, 1977). Therefore, self-efficacy beliefs will be explained in the following section.

2.2.1. Perceived Self-Efficacy Beliefs

"Perceived self-efficacy refers to beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (Bandura, 1997, p.3). Therefore, a high level of perceived self-efficacy refers to a high level of confidence in being able to do a particular action and vice versa (Pajares & Kranzler, 1995). Bandura (1997) stated that, there are four main sources of perceived self-efficacy, which are mastery experiences, vicarious experiences, verbal persuasion, and physiological and affective states. Mastery experiences refer to individual's own experiences which will be the most influential source of self-efficacy, and also, self-efficacy can be affected from others' experiences, which refers to the vicarious experience. Moreover, Bandura (1997) explained the effects of the other two sources as one's beliefs in the capability on a given task may be strengthened by social persuasion, which refers to verbal persuasion, and that an individual's physical status, stress level, and health functioning also affect self-efficacy, which refers to the source of physiological and affective states.

Determining self-efficacy beliefs enables researchers to see an individual's judgment about their capability of a specific behavior (Bandura, 1977; 2006; Pajares & Miller, 1994). Furthermore, perceived self-efficacy beliefs affect personal choices (Pajares & Kranzler, 1996), motivation towards a specific behavior (Bandura, 1977) and perseverance in given tasks (Bandura, 2006). These characteristics make perceived self-efficacy as a major determinant of behavior and thus, investigating these beliefs will help to predict future behaviors (Bandura, 1977). Therefore, research studies on prospective teachers' self-efficacy beliefs will reveal valuable information about their future teaching behaviors, which may form current educational policies (Pajares, 1992).

Although perceived self-efficacy beliefs affect future behaviors, this affect influence from the strength of these beliefs (Bandura, 1977). Hence, from the aspect of prospective teachers' self-efficacy beliefs, high self-efficacy levels on a specific task indicate a higher level of motivation, effort and perseverance in order to complete the task. Individuals with contradictory, low self-efficacy beliefs are reported to have low aspirations to complete the task and give up easily when compared with individuals having a high level of self-efficacy. Therefore, it is believed that investigating prospective teachers' perceived self-efficacy belief levels in using origami in mathematics education will provide valuable information on whether they will use origami as an instruction method in the future and how much effort they will put in using it in mathematics classes.

2.2.2. Mathematics Teaching Beliefs and Self-Efficacy Beliefs of Prospective Teachers

In the literature related to affective factors in mathematics education, teachers' beliefs in mathematics teaching is one of the main focuses (Thompson, 1992) since teachers' ways of thinking may affect their classroom practice (Nespor, 1987). Furthermore, research studies on prospective teachers' mathematics teaching beliefs are crucial since they are in the continuous process of forming beliefs and determining these beliefs may lead to predictions about their future practice in real classrooms (AlSalouli, 2004). At this point, research studies mostly focus on what affects prospective mathematics teachers' beliefs about teaching mathematics. In one of the studies related to this issue, Bulut and Baydar (2003) investigated prospective teachers' mathematics teaching beliefs and whether there are significant differences in terms of university and gender. In their survey, 79 prospective mathematics teachers from two different universities in Ankara/Turkey were selected as the sample. These teacher candidates were in their fourth year in the elementary mathematics teaching department. A Likert type scale was used as an instrument to measure beliefs regarding teaching mathematics, and t-test results revealed that there was no significant mean difference between male and female teacher candidates' beliefs regarding teaching mathematics. However, t-test results showed that there was a significant difference between the mean score of teacher candidates in terms of university. Prospective teachers who scored significantly higher on the scale had taken the school practice course twice, while others had only taken it once. Therefore, researchers concluded that teaching experience may lead to a significant difference between teacher candidates' teaching beliefs and highlighted the importance of experience in establishment of beliefs.

In another study, Wagner, Lee and Özgün-Koca (1999) investigated prospective teachers' mathematics teaching beliefs. Participants were selected from three different countries: the U.S.A., Turkey and Korea. Results yielded that Turkish and Korean prospective teachers had more traditional mathematics teaching beliefs when compared with American teacher candidates. American teacher candidates indicated that they preferred using manipulative and hands-on teaching methods, while Turkish and Korean prospective teachers preferred the lecturing method in mathematics lessons. Researchers indicated that this difference may arise from different experiences similar to the views of Bulut and Baydar (2003). Furthermore, researchers mentioned the importance of field experience and methodology courses in promoting mathematics teaching beliefs consistent with effective mathematics teaching aim. The importance of field teaching practice and methodology courses seem as important factors in forming beliefs about mathematics teaching. Similar to these studies, in the literature, the importance of field teaching practice is mentioned, and methodology courses seem as important factors in forming beliefs about mathematics teaching (Ambrose, 2001; Emenaker, 1995; Hart, 2002; Thompson, 1992).

Methodology courses have not always been effective in shaping prospective teachers' mathematics teaching beliefs consistent with the purpose of teacher education program. For instance, in the study of Reeder, Utley and Cassel (2008), it was found that throughout the two methodology courses, which support constructivist learning environments, prospective teachers' mathematics teaching beliefs remained static. Two hundred prospective teachers from a Midwestern American university were selected as the sample, and metaphors were used in order to establish their mathematics teaching beliefs. Although it was aimed to change their beliefs from traditional teaching to constructivist teaching methods, methodology courses seemed unsuccessful in this purpose. However, researchers mentioned that these kinds of studies are effective in understanding ongoing college courses.

In addition to studies on prospective teachers' mathematics teaching beliefs, their mathematics teaching efficacy beliefs have also been investigated in numerous studies in the literature. Teaching efficacy is defined as teachers' "beliefs in their ability to have a positive effect on students learning" (Ashton, 1985, p.142). Similar to the beliefs, methodology courses were one of the main focuses in this issue. For instance, Brand and Wilkins (2007) investigated the effects of methodology courses on prospective teachers' mathematics teaching efficacy beliefs. To this end, 44 prospective teachers in a master's degree program were selected as the sample of the study. Written reflection papers related to prospective teachers' experiences during the course were coded by researchers, and it was concluded that methodology courses improved prospective teachers' mathematics teaching efficacy beliefs. Most of the participants stated that experiences gained through the methodology course improved their teaching efficacy, confidence and furthermore reduced their teaching anxiety.

In another study, Swars, Smith, Smith and Hart (2007) investigated the effect of developmental teacher preparation program on elementary prospective teachers' mathematics teaching efficacy beliefs. In the program, there were two mathematics methodology courses and student teaching experience for teacher candidates. In this study, results revealed that there was a statistically significant increase in mathematics teaching efficacy beliefs of prospective teachers who had attended a developmental teacher education program. Therefore, researchers concluded that methodology courses and student teaching experience helped teacher candidates to improve their efficacy beliefs regarding mathematics teaching.

In the literature, there are also research studies which show that methodology courses or teaching experiences do not always lead to improvement in mathematics teaching efficacy beliefs. For instance, in a study which was conducted in Turkey, Işıksal and Çakıroğlu (2004) conducted a study on prospective mathematics teachers from two universities in Ankara/Turkey. They investigated whether prospective mathematics teachers' mathematics teaching efficacy beliefs differed by university and grade level. ANOVA results revealed that there was no statistically significant difference between teacher candidates from the two universities in terms of mathematics teaching efficacy beliefs. Furthermore, their mathematics teaching efficacy beliefs did not differ in terms of grade levels. Researchers concluded that similar lesson experience in these two universities may have led to an insignificant difference between prospective teachers from two universities. Furthermore, researchers stated that methodology and teaching experience courses should focus more on improving efficacy beliefs since there was no statistically significant difference between junior teacher candidates and sophomore teacher candidates in terms of mathematics teaching efficacy beliefs.

Bandura (1977) stated that mastery experiences are the major source of perceived self-efficacy and the findings of Brand and Wilkins (2007), and Swars et al. (2007) support this view by showing the effects of methodology courses and teaching experiences on prospective teachers' mathematics teaching beliefs. Although it is not possible to improve prospective teachers' mathematics teaching beliefs and efficacy beliefs merely through methodology courses and teaching experiences, these kinds of experiences seem to have a positive effect on their beliefs.

In this section, studies related with prospective teachers' both mathematics teaching beliefs and efficacy beliefs were presented. In the literature, both beliefs and self-efficacy beliefs are interpreted as important factors in mathematics education. Moreover, when these beliefs are of concern, gender differences in beliefs seem as an important factor and have been investigated in various studies. Therefore, the following section is dedicated to gender issues in mathematics education since one of the aims of the current study is to reveal gender differences in both beliefs and perceived self-efficacy beliefs of prospective elementary mathematics teachers towards using origami in mathematics education.

2.2.3. Gender: Is It a Relevant Factor on Beliefs and Self-Efficacy Beliefs?

The effect of gender has mostly been investigated in order to establish mathematics performance differences between male and female students. However, investigating gender differences in affective factors has a crucial role in organizing mathematics education environments (Li, 1999). Despite the importance of identifying gender differences in affective factors, there is lack of research in the investigation of this issue (Duatepe-Paksu, 2008).

Li (1999) mentioned that gender is an important factor in teachers' beliefs and consequently in teachers' classroom behaviors since it is widely accepted that beliefs affect acts. In accordance with this statement, Li (1999) also mentioned that female teachers prefer more student-centered and nontraditional teaching activities when compared with their male counterparts. However, in his broad review on studies related with gender differences in mathematics teaching, it is mentioned that female and male teachers hold similar beliefs about mathematics teaching and when a difference does appear, it is only on a small scale. From this aspect, investigating differences between male and female prospective teachers in using origami in mathematics education seems beneficial since origami is accepted as one of the student-centered activities as afore indicated.

Similar to the relationship between beliefs and gender, the relationship between gender and self-efficacy has not been studied very much since the focus is on the impact of gender on mathematics performance (Pajares & Miller, 1994). Therefore, there is lack of research investigating mathematical self-efficacy beliefs of prospective mathematics teachers in terms of gender (Işıksal, 2005). However, investigating prospective teachers' self-efficacy beliefs is crucial in order to develop education programs which improve the efficacy beliefs of prospective teachers (Işıksal & Çakıroğlu, 2005).

There are limited studies investigating gender and self-efficacy issues and there is no consensus about the relationship between gender and self-efficacy. For instance, in a study which was carried out with 350 university students, female students showed lower mathematical self-efficacy than their male peers, and it was found that female participants had a higher level of mathematics anxiety (Pajares & Miller, 1994). Contradictory to this study, Işıksal (2005) investigated the mathematical self-efficacy beliefs of 145 prospective mathematics teachers and found that there is no statistically significant difference between female and male participants in terms of mathematical self-efficacy beliefs. Similar results were gained from the study of Işıksal and Çakıroğlu (2005) and results revealed that both female and male teachers held similar mathematics teaching efficacy beliefs.

To sum up, there is a lack of research in the accessible literature regarding gender differences in using origami in mathematics education. As explained above, revealing gender differences is accepted as an important factor for mathematics education and there is a need for further research in order to understand this issue in depth. Therefore, investigating gender differences in beliefs and perceived self-efficacy beliefs of prospective teachers towards using origami in mathematics education would be beneficial for both origami related literature and mathematics education literature.

2.3. Summary

Review of the accessible literature showed that origami is seen as an important teaching tool in education, particularly in mathematics education. Therefore, its effects in mathematics education have been investigated especially through experimental research designs. Results of these studies generally revealed significant differences in favor of origami based mathematics instruction (e.g., Akan-Sağsöz, 2008; Çakmak, 2009; Kavici, 2005; Yuzawa & Bart, 2002). However, there are also studies in which origami based mathematics instruction have not significant effect (e.g., Boakes, 2009). Although these research studies are promising in order to understand possibilities of origami as a mathematics teaching tool, further research studies on origami based mathematics education from different aspects would be beneficial to understand its effect in mathematics education.

Studies on using origami in mathematics education are generally based on experimental research designs with the participation of students. However, research studies with different samples like prospective or in-service teachers and studies on different issues like affective factors would be beneficial for further insight on origami based mathematics education since beliefs would affect teaching practices (Pajares, 1992).

Although origami was not studied extensively with prospective teachers in terms of affective factors, affective issues are really important as explained in the second part of the literature review. Therefore, mathematics teaching beliefs of teachers and prospective teachers have been widely investigated in the literature in order to predict their teaching behaviors and furthermore organize teacher education programs. Moreover, beliefs of prospective teachers in specific mathematics teaching methods, such as use of technology , use of history, and use of music have been investigated in the literature in order to determine their beliefs and anticipate their future teaching decisions and shape teacher education programs accordingly (e.g., Alpaslan, 2011; An, Ma & Capraro, 2011; Wachira, Keengwe & Onchwari, 2008).

Therefore, investigating beliefs towards using origami in mathematics education, which can be accepted as one of the specific mathematics teaching tool, would enable the prediction of teacher candidates' future decisions in using origami in mathematics lessons.

To sum up, origami is regarded as an important teaching tool in national and international mathematics education programs and growing attention is attributed to studies on these topics. However, despite the educational outcomes of studies related with prospective teachers’ beliefs and efficacy beliefs, there seems to be a gap in the origami related literature regarding these topics. Therefore, the aim of the current study is help to fill this gap in the literature by investigating prospective teachers' beliefs and perceived self-efficacy beliefs in using origami in mathematics education and identifying gender differences in these beliefs.

CHAPTER 3

METHODOLOGY

This chapter represents research design and procedures in order to give detail information on the methodology of the current study. This chapter is divided into seven subsections namely; research design, population and sample, data collection instruments, data collection procedures, data analysis procedures, internal and external validity threats and lastly assumptions and limitations of the study.

3.1. Research Design of the Study

The current study aims to develop valid and reliable scales in order to measure beliefs and perceived self-efficacy beliefs towards using origami in mathematics education and investigate prospective elementary mathematics teachers' beliefs and perceived self-efficacy beliefs towards using origami in mathematics education. In accordance with this purpose, cross sectional survey, which enables researcher to collect data at one point time to measure the characteristics and opinions of participants on a specific topic, was selected as research design (Fraenkel & Wallen, 2006). Another purpose of the current study is investigating gender differences in prospective teachers' beliefs and perceived self-efficacy beliefs in using origami in mathematics education. For that purpose, casual-comparative research design was used since this research design enables researcher to investigate differences between already existing groups and generally used to establish discrepancies between males and females (Fraenkel & Wallen, 2006). Therefore, it can be stated that both survey and causal-comparative research design is used in accordance with the purposes of the study.

3.2. Population and Sample of the Study

The target population of the study is all Turkish prospective elementary mathematics teachers who have lesson experience about origami mathematics lessons. Accessible population of the study is all prospective elementary mathematics teachers who have lesson experience about origami based mathematics lessons in four different regions of Turkey which are Aegean, Central Anatolia, Marmara, and Black Sea regions.

As a sampling method, purposive sampling which enables researcher to select sample in accordance with the specific purpose of the study (Fraenkel & Wallen, 2006) was used. Purposive sample is generally used when the participants should be knowledgeable on a specific topic and this characteristic make purposive sampling robust even it is compared with the random sampling methods (Dolores & Tongco, 2007). Most of the prospective mathematics teachers know what origami is but very few of them have an idea about its relationship with mathematics. Investigating beliefs and self-efficacy beliefs of prospective teachers who don't have any knowledge about its relationship with mathematics wouldn't be realistic since beliefs and self-efficacy beliefs are mostly based on experiences as explained in the previous chapter. Therefore, purposive sampling method was used and participants were selected according to their lesson experience about origami based mathematics lessons. There are five universities in the target population of study which offer elective origami course for prospective elementary mathematics teachers and in addition to these universities one university offer origami based mathematics instruction experience through method and school experience courses. Therefore, three of the possible six universities' prospective elementary mathematics teachers were selected as the sample of the pilot study and the other three universities' prospective mathematics teachers were selected as the sample of the main study. Detailed information about the participants of pilot and main study is given in the following section.

3.2.1. Participants of the Pilot Study

OMEBS and OMESS were administered simultaneously to 143 prospective mathematics teachers from three different universities in Ankara. Participating universities were selected from Ankara since available to the researcher and moreover these teacher candidates have origami lesson experience. Seventy three of these 143 prospective teachers had specific elective course about using origami in mathematics education, and participants who had not specific origami course had lesson experience in method and/or school practice course about using origami in mathematics education. There are also prospective teachers who gain experience about origami through personal interest and following origami related publications such as books, journals and websites. Detailed information about origami experience of participants is given with Table 1.

Table 1

Information about Pilot Study Participants' Origami Experience

Experience	N	%
Attending lesson about origami	73	51
Experimenting and/or observing activity during method course	33	23
Experimenting and/or observing activity during school practice	29	20
Personal interest	59	41
Following publications (books, web sites, journals etc.)	22	15
Other types of experience	14	10

Fifty percent of the participants stated that they sometimes follow publications (books, journals), websites about origami while 44 percent of participants stated that they never follow publications, websites about origami. Only 6 percent of participants stated that they usually follow origami related websites and publications. These statistics indicated that all of the participants had a lesson experience about origami based mathematics. Moreover, more than half of them follow origami related publications.

3.2.2. Participants of the Main Study

Similar to the data collection process of pilot study, OMEBS and OMESS were administered simultaneously to 299 prospective elementary mathematics teachers from three universities located in three different regions of Turkey.

In the cover page of OMEBS and OMESS, prospective teachers answered to questions about their university, year of enrollment in teacher education program, gender, high school, experiences about origami and interest about origami related publications.

Information about prospective teachers’ year of enrollment in teacher education program regarding gender is presented below in Table 2.

Table 2

Demographic Information on Year of Enrollment in Teacher Education Program Regarding Gender

Prospective Teachers	Female		Male		Total	
	N	%	N	%	N	%
Freshman	-	-	1	0.33	1	0.33
Sophomore	101	33.78	45	15.05	146	48.83
Junior	98	32.78	33	11.04	131	43.81
Senior	12	4.01	9	3.01	21	7.02

As indicated in Table 2. more than ninety percent of the prospective teachers are in the second or third grade. In addition to these participants, there are 21 senior participants in the study and there is only one freshman prospective teacher participated into the study. In the current study, participants were selected according to origami lesson experience. In Turkey, origami course for elementary mathematics teachers are offered as elective for generally second or third graders depending on the university. Therefore, most of the participants in the current study are from second or third grade thus, potential role of year of enrollment in prospective teachers' origami related beliefs and perceived self-efficacy could not be investigated in the current study. Similar to the general education faculties’ profile in Turkey, female participants are far more than male participants in this study. There are 211 female participants (% 70.6) and 88 male participants (% 29.4) in the current study.

According to the graduated high school information, there are 125 prospective teachers (% 41.9) graduated from Anatolian High School, 120 prospective teachers are (% 40.3) from Anatolian Teacher Training High School, 43 are (% 14.4) from General High School, 6 prospective teachers are (% 2) from Foreign Language Weighted High School and 5 prospective teachers are (% 1.67) from different types of high school.

In OMEBS and OMESS, prospective teachers were also asked about their origami experience and information about participants' answers to this question is presented in Table 3.

Table 3

Information about Prospective Teachers' Experience on Origami

Experience	N	%
Having lesson about origami	299	100
Experimenting and/or observing activity during method course	72	24.1
Experimenting and/or observing activity during school practice	61	20.4
Personal interest	100	33.4
Following publications (books, web sites, journals etc.)	49	16.4
Other types of experience	6	2

As shown in Table 3, all of the participants have an experience about origami through elective courses in origami based mathematics. Furthermore, 72 prospective teachers (% 24.1) gained experience about origami based mathematics lessons through method courses and 61 prospective teachers (% 20.4) gained experience through school practice course. Furthermore, 100 participants (% 33.4) stated that they have personal interest to origami while 49 participants (% 16.4) indicated that they follow origami related publications.

As indicated with Table 4, question of "How often do you follow origami related publications?" was asked to participants and 87 participants answered as never, 199 participants answered as sometimes, 12 participants answered as often and only one participant answered as always. In other words, more than seventy percent of the participants follow origami related publications such as books, web sites or magazines.

Table 4

Prospective Teachers' Origami Related Publications Following Frequency

	How often do you follow origami related publications?
Never	87 (% 29.1)
Sometimes	199 (% 66.6)
Often	12 (% 4)
Always	1 (% 0.3)

3.3. Data Collection Instruments

In the current study, data was collected through Origami in Mathematics Education Belief Scale (OMEBS) and Origami in Mathematics Education Self-Efficacy Scale (OMESS). In accordance with the purpose of the study, scales were developed in order to obtain prospective teachers' beliefs and perceived self-efficacy beliefs towards using origami as a teaching tool in mathematics education. Developing process of these scales is explained in detail below.

3.3.1. Origami in Mathematics Education Belief Scale

Origami in Mathematics Education Belief Scale (OMEBS) consists of 26 items within a 6-point scale. All the items aim to establish prospective teachers' beliefs towards using origami as an instruction method in mathematics lessons. In accordance with this aim, 1 means "Completely disagree" with the statement in the item and 6 means "Completely agree" with the statement. The lowest score which could be obtained in the scale is 26 and the highest score which could be obtained in the scale is 156. Scoring high in this scale refers to positive beliefs to use origami in mathematics education and scoring low in this scale refers to negative beliefs regarding the use of origami in mathematics education. How the items were prepared is explained below in the subheading of preparation of OMEBS items.

3.3.1.1. Preparation of OMEBS Items

Items in OMEBS were constructed, after a detailed literature review about origami related studies and observations during an elective course regarding origami based mathematics instruction in a university. In the broad review of literature, ERIC, EBCOhost, and ULAKBIM were used as databases. The research studies that obtained from these databases explored carefully in the process of item writing. In these studies, origami has been studied from different aspects in mathematics education. Although, mathematical benefits of origami like improving spatial visualization, enhancing geometrical terminology of students, possible effect on algebraic thinking has been the main focus (e.g., Boakes, 2009; Çakmak, 2009; DeYoung, 2009; Georgeson, 2011; Higginson & Colgan, 2001), effects of origami on attitudes of students and the nature of the origami as a teaching tool has also taken a place in the origami related literature (e.g., Boakes, 2008, 2009; Cipoletti & Wilson, 2004; Georgeson, 2011). Literature review revealed that origami has been studied in mathematics education from different perspectives, but neither a theoretical structure nor a scale for specifically origami in mathematics education has been proposed yet. For that reason, 35 items in the item pool were written in accordance with the most mentioned issues about origami based mathematics instruction and observations of researcher in origami course offered for prospective mathematics teachers in a university. These items were evaluated by two experts, from mathematics education and educational measurement departments, and based on their evaluations some items were revised and some items were deleted according to their inappropriateness for the purpose of the scale.

When deciding on number of scale points, Krosnick and Fabrigar (1997) suggest using 5 to 7 rating scale since they seem to be more reliable and valid than shorter and longer ones according to the researches in the literature. Furthermore, they suggest not using midpoints since using midpoints may degrade the quality of the scale. With respect to these suggestions, number of the scale point was decided as 6.

After the item writing process, interview was conducted with three prospective teachers to understand their stance to the items in the scale. At first, teacher candidates stated that they are not familiar with Likert scale with 6 points and they prefer to answer Likert scale with 5 points. However, they also stated they think more about the items when there is no midpoint, so if there is a midpoint in the scale, they prefer to choose midpoint for most of the items. Therefore, number of scale points stayed same. After the interview, some items were revised since teacher candidates found them difficult to understand. For example, "Using mathematical terminology in Origami activities improves students' mathematical language." changed to "Using mathematical terms during Origami activity helps to improve mathematical language of students". Similarly, slender changes were applied for a few items to improve understandability of the items by prospective teachers.

After the interview with prospective teachers, scale was sent to 3 experts to be evaluated. One of the experts is from the department of mathematics education, the other expert is from science education department who has so many research studies on beliefs and self-efficacy beliefs of prospective teachers, and the last expert is from the mathematics education who has been giving course about origami based mathematics lessons for a long time. Experts were asked to evaluate the items according to their appropriateness for the purpose of the scale, and furthermore their understandability. All the experts stated that all items are appropriate for the scale. However, on a few items slender changes were made for better understandability according to the experts' opinions. For instance in OMEBS, "Children who made Origami can learn geometry easily in school years" was changed to "Children who made Origami in preschool time learn geometry subjects easily in later years".

Finally, there were 27 items for the pilot study of OMEBS and pilot study is explained in the result section.

3.3.2. Origami in Mathematics Education Self-Efficacy Scale

Origami in Mathematics Education Self-Efficacy Scale (OMESS) consists of 8 items within a 9-point scale. Items in the scale aim to measure prospective teachers' perceived self-efficacy beliefs towards using origami in mathematics education. Scale scores range from 1 that means insufficient perceived self-efficacy to 9 which means sufficient perceived self-efficacy to use origami effectively as a teaching tool. The lowest score which could be obtained in the scale is 8 and the highest score which could be obtained in the scale is 72. Scoring high scores in the currents scale means that feeling confident to use origami in mathematics education and scoring low in this scale refers to not feeling confident in using origami in mathematics education. How the items were prepared is explained below in the subheading of preparation of OMESS items

3.3.2.1. Preparation of OMESS Items

Similar process with OMEBS was followed for Origami in Mathematics Education Self-Efficacy Scale (OMESS). Studies in databases such as ERIC, EBCOhost, and ULAKBIM were investigated and furthermore, observations during origami lesson for prospective mathematics teachers helped to develop items in this scale. As explained in the literature chapter, origami based mathematics lessons have own lesson structure and so have own lesson structure, teacher requirements and therefore, in OMESS, eight questions were prepared in order to determine how well prospective mathematics teachers see themselves to use origami as a teaching tool in mathematics lessons. When deciding on number of points in the scale suggestion of Bandura (2006) was the basis since he suggested using scales with longer number points since people don't choose the extreme points when measuring self-efficacy. Eight questions in the scale were interpreted by two experts from educational measurement and mathematics education departments and found as consistent for the aim of the scale. Furthermore, cognitive interview with three prospective teachers was conducted and slender changes on two items were made for the better understanding.

After the cognitive interview, scale was sent to three experts who also interpreted the OMEBS. Although slender changes on writing style were made, there was no item deleted since experts stated that all the items are appropriate to measure prospective teachers' perceived self-efficacy beliefs on using origami in mathematics education.

After this process, eight items for OMESS were ready to be used in the pilot study which is explained in the result section and sample items from the scale are demonstrated with Table 5.

Table 5

Sample Items for OMESS

Sample Items
How well do you feel to use Origami effectively in mathematics education?
How well do you feel to plan a lesson in which origami activities will be used?

3.4. Data Collection Procedure

After getting approval from Middle East Technical University Ethical Committee, necessary corresponds were conducted with the other participating universities and all necessary permissions were taken. Subsequently, pilot study was conducted and according to the results of the pilot study data collection process for the main study started. Data for the current study was collected during the 2011-2012 academic year in the spring term. In all participating universities, data collection process was administered by the researcher except in one university. However, instructors in this university who administered this process were informed about the details of the study and data collection procedures. Data was collected at the beginning of one of prospective teachers' college courses in their regular classrooms. Before implementing the scales, participants were informed about the purpose of the study and just voluntary prospective mathematics teachers participated into the study. In addition to the willingness of participants, there is no question about their personal identity in order to make them comfortable and give honest responds. Both of OMEBS and OMESS were implemented simultaneously and approximately 20 minutes lasted.

3.5. Data Analysis Procedure

In order to understand the validity and reliability of the scales, exploratory factor analysis was conducted with PASW18 and confirmatory factor analysis was conducted with LISREL 8.8. Furthermore, in order to understand beliefs and perceived self-efficacy beliefs towards using origami in mathematics education, descriptive statistics techniques in PASW18 such as mean scores, maximum-minimum values, percentages for alternatives of items and standard deviations were calculated. The current study also aims to answer the research question of whether beliefs and perceived self-efficacy beliefs of prospective teachers differ by gender and to be able to answer these questions independent samples t-test which is a type of inferential statistics was used via PASW 18.

3.6. Internal and External Validity

In this section of the study, threats to internal and external validity and precautions taken to overcome these threats explained in detail.

3.6.1. Internal Validity

If a research study has internal validity, it means that observed results on the dependent variable is due to the independent variable rather than any other exterior variable (Fraenkel & Wallen, 2006). Survey and casual comparative studies are vulnerable to the mortality, subject characteristics, location, instrumentation and instrument decay internal validity threats (Fraenkel & Wallen, 2006). These threats and precautions to these threats are explained in detail below.

Mortality refers to loss of the participants who couldn't complete the instrument during the data collection procedure (Fraenkel & Wallen, 2006). Being a cross sectional survey makes the current study less vulnerable to mortality threat when compared with longitudinal survey studies. However, there were absent teacher candidates during the data collection procedure but the percentage of these prospective teachers were not more than ten percent. Furthermore, before implementing the scale the purpose of the study was explained to participants and just voluntary teacher candidates participated into the study. Only, two prospective teachers rejected to fill the instruments and no participants give up filling the instruments after started to answer the items in the scale. Therefore, mortality does not seem as a threat for the current study.

Subject characteristics threat refers to effect of some characteristics of participants on the measured variable (Fraenkel & Wallen, 2006). Although, it is not possible to claim that compared groups have totally same characteristics, they share similar characteristics in general. Female and male participants of this study have similar lesson experience since Elementary Mathematics Education programs are mostly standardized in Turkey. When the origami experience level which may have an effect on the beliefs and self-efficacy is investigated, it was seen that all the participants have elective origami course experience and moreover their other experiences on origami such as personal interest, following publications do not differ in terms of gender. Therefore, it is presumed that subject characteristics threat minimized in this study.

Location threat refers to undesirable effects of the data collection location on the responses of participants (Fraenkel & Wallen, 2006). Although, it was not possible to keep location constant for all participants, data was collected in regular classrooms of prospective teachers and no undesirable effects of the place were observed during the data collecting process which helped to minimize the effect of location on responses.

In order to minimize instrumentation threat, in data collecting process and scale development process researcher was careful not to affect the responses of participant. For that aim, both positive and negative items were used in the scale not to distort the responses of participants. Furthermore, using Likert type scale make it easy to administer, which took approximately 20 minutes to administer, and easy to objectively evaluate which helped to minimize possible instrument decay threat.

3.6.2. External Validity

"The extent to which the results of a study can be generalized determines the external validity of the study" (Fraenkel & Wallen, 2006, p.104). In the current study, purposive sampling which enables to select participant according to judgment related to the specific purpose of the scale. Purposive sampling method is a nonrandom sampling method and in nonrandom samples, it is suggested to describe characteristics of participants in detail and moreover, replication will improve the generalizability of the results (Fraenkel & Wallen, 2006). Therefore, characteristics of the sample were given in detail and moreover, studies with different participants are suggested for the generalizability of the results obtained in the current study. However, participants of the study have similar conditions and lessons with the population which is desirable for the ecological generalizability of the study.

3.7. Assumptions and Limitations of the Study

First of all, it is assumed that all prospective elementary mathematics teachers who participated into this study had answered the scales in accordance with their own opinions without interacting with other participants and also without being effected from the data collector and the instructor of course at that time.

Researcher of the current study administered the data collecting process in all participating universities except one university. In this exception university, data collecting process was administered by another faculty member who was informed about the details of the study and data collection procedure. Therefore, it is assumed that all participants in the current study have experienced similar data collection procedures.

Using nonrandom sampling method limits the generalizability of observed results in research design (Fraenkel & Wallen, 2006). However, using purposive sampling method, which is one of the nonrandom sampling methods, seems most appropriate for the purpose of the current study in accordance with the explanations in the population and sample section of the current study. Therefore, using nonrandom sampling method accepted as the major limitation of the study and suggested to replicate the study with different samples in order to improve generalizability of observed results of the current study.

CHAPTER 4

RESULTS

This study aims to develop valid and reliable scales in order to measure beliefs and perceived self-efficacy beliefs towards using origami in mathematics lessons, and secondly measuring Turkish prospective elementary mathematics teachers' beliefs and perceived self-efficacy beliefs towards using origami in mathematics education. As a last purpose, difference between male and female prospective teachers' beliefs and perceived self-efficacy beliefs in using origami in mathematics education is investigated. In accordance with these purposes, data analysis results are explained briefly in this section. Therefore, this chapter includes exploratory and confirmatory factor analysis of data collection instruments, descriptive analysis results for the data obtained from OMEBS and OMESS and lastly, independent sample t-test results in order to test the differences in beliefs and perceived self-efficacy beliefs regarding gender.

4.1. Validity and Reliability Evidences for the Data Collection Instruments

In the current study, data collected through newly developed scales called OMEBS and OMESS and for the newly developed scales, it is essential to establish factor pattern via exploratory factor analysis and then, confirm this factor pattern via confirmatory factor analysis (Çokluk, Şekercioğlu & Büyüköztürk, 2010). Therefore, exploratory factor analysis was applied with the data obtained from pilot study and subsequently, confirmatory factor analysis was applied with the data obtained from main study in order to get validity evidences for the data collection instruments. Exploratory and confirmatory factor analysis results for OMEBS and OMESS is explained in the following section.

4.1.1. Exploratory Factor Analysis Results

OMEBS and OMESS were administered to 143 prospective elementary mathematics teachers in the pilot study and the data obtained from pilot study was analyzed with exploratory factor analysis techniques through PASW18. Exploratory factor analysis results and hypothesized factor pattern of OMEBS and OMESS are explained in detail below.

4.1.1.1. Exploratory Factor Analysis Results of OMEBS

Exploratory factor analysis was applied by using the PASW18 statistical package programme to establish the factor structure of OMEBS. Before conducting the factor analysis, KMO measure of sampling adequacy and Bartlett's test of sphericity was checked whether these are appropriate for factor analysis. For OMEBS, KMO value was calculated as 0.90 and can be interpreted as very good (Çokluk, Şekercioğlu & Büyüköztürk, 2010). Bartlett's test of sphericity was found as significant (BTS Value=1904.63) which is desirable for the factor analysis (Büyüköztürk, 2002). These values indicated that the data set of belief scale is appropriate for factor analysis. Maximum likelihood extraction method was used since it gives the best result for normally distributed samples (Costello & Osborne, 2005). Subsequently, factor analysis was applied and 6 factors emerged which have eigenvalues greater than one as indicated with Table 6 However, it should be noted that, first two factors' eigenvalues are quite higher from the other four factors and last four factors' eigenvalues are close to one.

Table 6

Exploratory Factor Analysis Results about Initial Eigenvalues of OMEBS

	Initial Eigenvalues		
Factor	Total	% of Variance	Cumulative %
1	10.12	37.46	37.46
2	2.36	8.74	46.21
3	1.50	5.56	51.76
4	1.30	4.80	56.56
5	1.15	4.25	60.81
6	1.03	3.83	64.64
7	0.95	3.51	68.15

Note. Maximum likelihood extraction method for the factor analysis was used

Costello and Osborne (2005) stated that establishing factor number by eigenvalues greater than one method may lead to too many factors and thus, using scree plot to interpret the number of factors will give best result. As shown in Figure 1, third factor seems to be breaking point in the scree plot which means there are two factors which are above the break point.

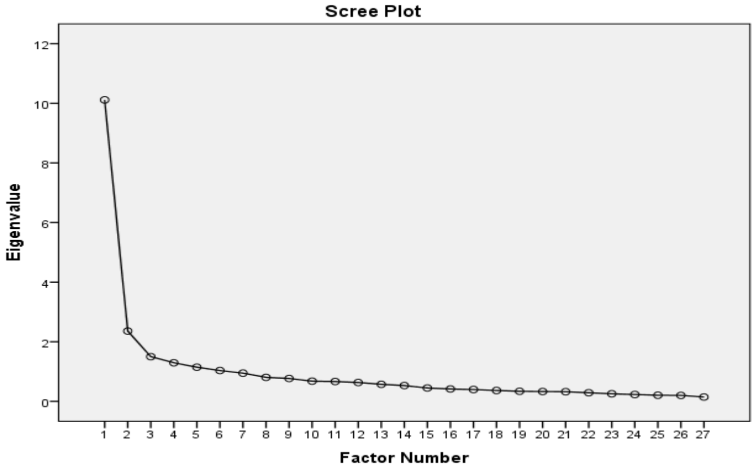

Figure 1. Scree plot for OMEBS

According to the scree plot and eigenvalues, it was decided that two factor structure is appropriate for this scale since third factor seems to be the breaking point in the scree plot and first two factors' eigenvalues are quite higher than the other factors. These two factors explain almost 46 percent of the total variance.

Subsequently, oblique rotation was applied to be able to interpret the results since in social sciences correlation among factors are expected and oblique rotation gives better results when the factors are related (Costello & Osborne, 2005).

According to Costello and Osborne (2005), item is acceptable for the scale if its communality value is greater than 0.4. In this data set, all the communality values of items are higher than 0.4, except the item 18, 21, 24. However, these three items' communality values are very close to 0.4. Therefore, it was concluded that all the items in the scale are appropriate for the scale according to their communality values. Stevens (2002) suggested using items with minimum 0.30 factor loadings. In this scale, all the items have higher factor loadings than 0.30 and furthermore, there is no cross loading for any of the items in this scale. Therefore, it was concluded that two factor structure is appropriate to be interpreted.

Items loaded in the first dimension are related with, advantages of using origami in mathematics education. These 16 items are about mathematical benefits of origami, instructional and attitudinal benefits of origami in mathematics education. Therefore, this dimension was named as *benefits of origami in mathematics education*. Eleven items which were loaded in the second dimension are related with negations and limitations of using origami in mathematics education. So, this dimension was named as *limitations of using origami in mathematics education*. Factor matrix of OMEBS items in the pilot study is given in Appendix A.

As stated above, second dimension is named as limitations of using origami in mathematics education but there are a few items which are negative beliefs rather than the limitation beliefs. Therefore, these three items are recommended to reverse into positive to differentiate them from limitation beliefs and thus, it is expected that in the further implementations of this scale, these three items will load on the first factor. Item revisions are displayed below with Table 7.

Table 7
Revised Items for OMEBS

Item	Item in the scale	Item with revision
5	Origami activities are not effective for improving students' problem solving abilities	Origami helps to students to improve their problem solving abilities.
9	Mathematics lessons in which origami activities are used are not attractive for students.	Mathematics lessons in which origami activities are used are attractive for students.
15	Origami is not an instruction tool which can be used in mathematics education.	Origami is an instruction tool which can be used in mathematics education.

In addition to these revisions, item 3 which is “It is a waste of time to use origami in mathematics lessons” is recommended to change into “It takes long time to use origami in mathematics lessons”. By doing so, it is aimed to make item more suitable for the limitation beliefs. Similarly, item 23 which is “Using origami in mathematics education reduces students’ interest to mathematics lessons” is recommended to delete since it is not a limitation belief. If it is reversed into positive, it is thought that it will have a similar meaning to item 9. Therefore, it is recommended to delete this item from the scale. Moreover, item 17 which is “It is difficult to control the class in origami based mathematics lesson” is recommended to change into “Origami cannot be used for mathematics lessons in crowded classes”. This item is related with both classroom management and limitation belief regarding origami. So, it is thought that it has the lowest factor loading in the scale and by the revision, it will be more appropriate for the second factor. After these revisions, for the further implementations of this scale, it is expected that, it will give the two factor structure. The first factor is *benefits of origami in mathematics education* with 19 items, and the second factor is *limitations of using origami in mathematics education* with 7 items as indicated in Table 8.

Table 8
Expected Items According to Dimensions of OMEBS

Name of the factor	Item number
Benefits of origami in mathematics education	1-2-5-6-7-8-9-10-12-13-15-16-19-20-21-22-24-25-26
Limitations of using origami in mathematics education	3-4-11-14-17-18-27

After deciding on factor pattern of the scale, Cronbach alpha coefficient values were calculated for each dimension of OMEBS in order to interpret the internal consistency of prospective teachers' answers to the scale. As indicated with Table 9, Cronbach alpha coefficient values were calculated as 0.93 and 0.84 respectively for the two dimensions in the scale, which can be interpreted as satisfactory (Pallant, 2007). Furthermore, deleting any of the items did not increase Cronbach alpha coefficient value which indicates that all of the items have a positive impact on reliability. To sum up, there seems to be no problem for the internal consistency of each dimension of OMEBS.

Table 9
Reliability Analysis for Each Dimension of OMEBS

Scale	Origami in Mathematics Education Belief Scale	
Dimension	Benefits of origami in mathematics education	Limitations of using origami in mathematics education
Number of items	16	11
Cronbach Alpha	0.93	0.84

4.1.1.2. Exploratory Factor Analysis Results of OMESS

Pilot study of OMESS was conducted with same participants of the pilot study of OMEBS at the same time. Similar to OMEBS, there is no existing factor structure for OMESS and thus, exploratory factor analysis was applied in order to determine its factor pattern.

For this scale KMO value was calculated as 0.93 which is quite high and Bartlett’s test of sphericity was found as significant (BTS Value=956.07). According to these values, it was concluded that the data set of self-efficacy scale is appropriate for factor analysis. Similar reasons with OMEBS; Maximum Likelihood extraction method was used.

In order to decide on factor number, both eigenvalues and scree plot are interpreted. According to eigenvalues as shown with Table 10, there is only one factor which is higher than one and this factor's eigenvalues is quite higher than the others.

Table 10
Exploratory Factor Analysis Results about Initial Eigenvalues of OMESS

Factor	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	5,818	72,727	72,727
2	0,545	6,807	79,534
3	0,413	5,161	84,695

According to scree plot as illustrated in Figure 2, second factor seems to be the breaking point of OMESS which can be interpreted as one factor structure is appropriate for the scale.

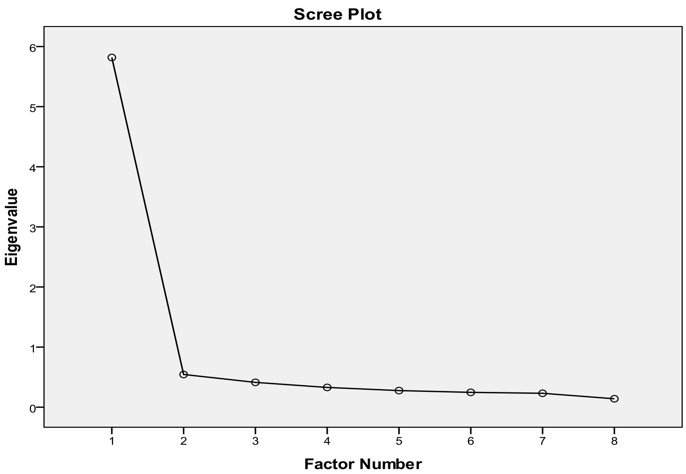

Figure 2. Scree plot for OMESS

Both eigenvalues and scree plot indicated that there is one factor for this scale. This one factor explains almost 73 percent of the total variance which is a very high proportion.

As can be seen in factor matrix of OMESS which is given in Appendix B, all the items have factor loadings higher than 0.30 while there is no cross loading. Furthermore, communality value of each item is higher than 0.40. After deciding on the number of factors in the scale and checking their communality values and factor loadings, factor matrix was interpreted since there is only one dimension. This dimension was named as *perceived self-efficacy in using origami in mathematics education.* Items in this dimension are about how preservice teachers see themselves in using origami in mathematics education. No changes or revisions were made for the items since all the values are appropriate for factor interpretation and furthermore, consistent with the aim in scale development process.

In addition to the exploratory factor analysis for the construct validity of scale, reliability analysis through calculating Cronbach alpha value applied with PASW18, statistical package program. The only dimension's Cronbach alpha coefficient value calculated as 0.95 which is quite satisfactory for the internal consistency (Pallant, 2007).

After the pilot study, hypothesized factor pattern of OMEBS and OMESS was established and these hypothesized models were tested with confirmatory factor analysis which is explained in detail in the following section.

4.1.2. Confirmatory Factor Analysis Results

Confirmatory factor analysis is a higher order research technique which enables researcher to test the relationship between observed variables and latent variables (Tabahnick & Fidell, 2001). For the newly developed scales in order to give evidences for the validity of scales, it is suggested to establish factor pattern of scales with exploratory factor analysis and then confirm the fit of this pattern with confirmatory factor analysis (Çokluk, Şekercioğlu and Büyüköztürk, 2010). In accordance with this suggestion, exploratory factor analysis was conducted for OMEBS and OMESS with pilot study and moreover, confirmatory factor analysis was applied for these scales with the main study.

Confirmatory factor analysis procedure and results for OMEBS and OMESS is explained in detail under two subheadings below.

4.1.2.1. Confirmatory Factor Analysis Results of OMEBS

According to the exploratory factor analysis results of OMEBS, factor pattern with two dimensions was established. In order to confirm this factor structure, confirmatory factor analysis was applied with the data obtained in the main study through the statistical program of LISREL 8.8.

Before conducting confirmatory factor analysis, missing values were replaced with mean scores since the proportion of missing values are lower than ten percent. After this step, hypothesized model was tested with confirmatory factor analysis. In accordance with the findings of exploratory factor analysis, it is hypothesized that items 1,2,5,6,7,8,9,10,12,13,15,16,19,20,21,22,23,24 and 25 load on the dimension of *benefits of origami in mathematics education* and items 3,4,11,14,17,18 and 26 load on the dimension of *limitations of using origami in mathematics education*. Hypothesized model for the OMEBS and confirmatory factor analysis results is given with Figure 3.

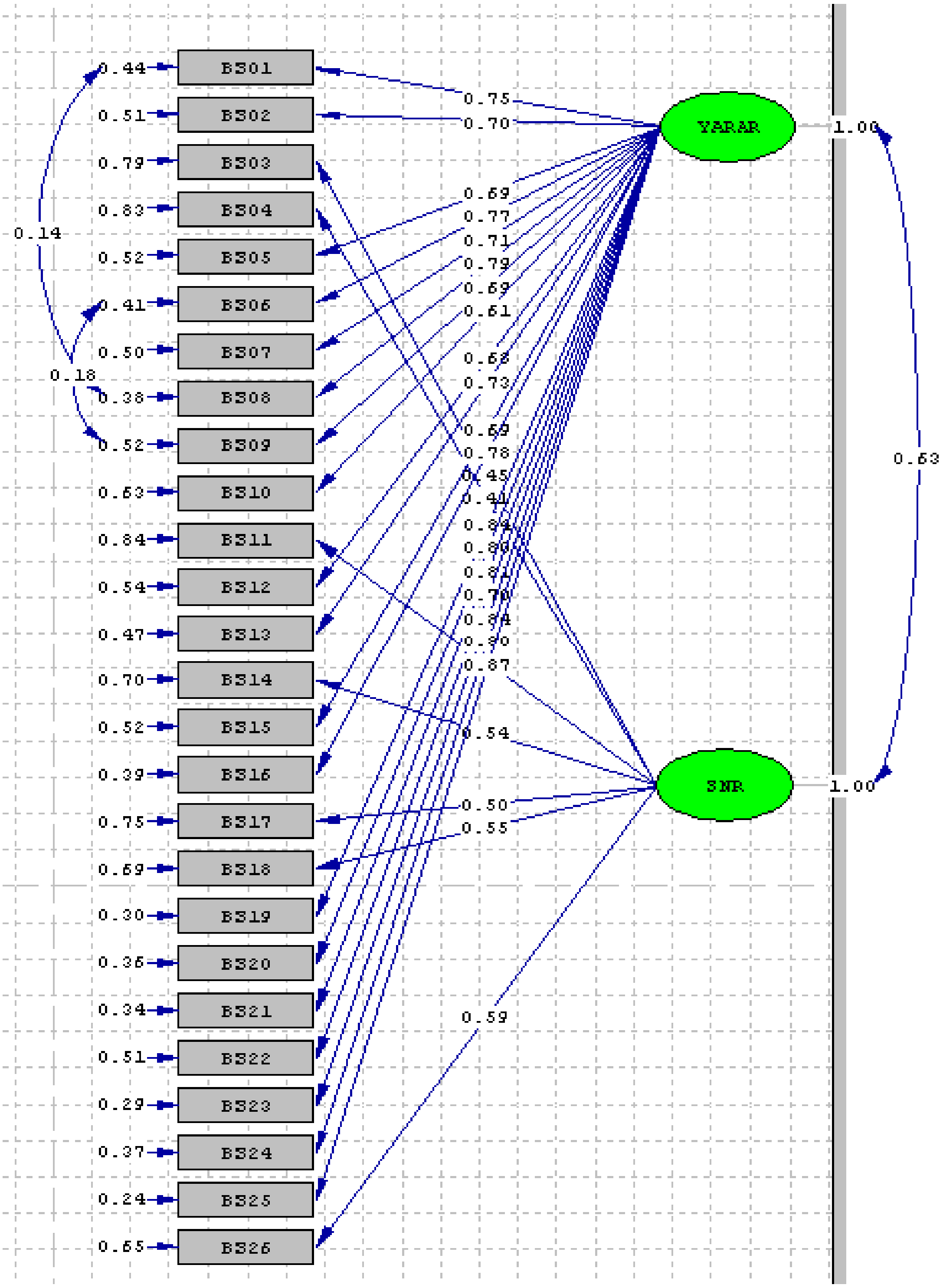

Figure 3. Hypothesized Model and Confirmatory Factor Analysis Results of OMEBS

Root Mean Square Error of Approximation (RMSEA) is one of the fit indexes offered by confirmatory factor analysis. According to Steiger (1990), if the RMSEA value is lower than 0.10, it can be accepted as an evidence for the good fit of tested model (as cited in. Kelloway, 1998). However, in the first step, RMSEA value was found as more than 0.10 for OMEBS. However, with two modifications offered by the program, RMSEA value was calculated as 0.091 which was interpreted as good fit. Modifications were made between the item "Using origami activities in mathematics lessons makes lessons more amusing" and "Mathematics lessons in which origami activities are used took attention by students", moreover between "Origami is beneficial to make some abstract mathematical concepts more concrete" and "Origami make easy to teach geometrical concepts". After the modifications finding RMSEA value under 0.10 accepted as one of the evidences of good fit but investigating more fit indexes to evaluate the tested model is suggested in the literature (Matsunaga, 2010). For that reason, indices such as Normed Chi-Square (NC), Comparative Fit Index (CFI) and Goodness of Fıt Index (GFI) were evaluated for OMEBS. Normed Chi-Square is calculated by dividing Chi-Square value to the degrees of freedom value was calculated as 3.45 for OMEBS. Furthermore, CFI and GFI values were both calculated as 0.90 for OMEBS. Detailed information about evaluations of these fit indices is given in the discussion section.

In addition to the fit indices via confirmatory factor analysis, Cronbach alpha coefficients were calculated for each dimension of the scale in order to check the internal consistency of the data obtained from main study. Cronbach alpha coefficients were calculated as 0.95 and 0.66 respectively for the two dimensions of

OMEBS. Although first dimensions' Cronbach alpha coefficient value is interpreted as quite high, the value of 0.66 for the second dimension is interpreted as low (Pallant, 2007). However, Pallant (2007) stated that, low Cronbach alpha values are not uncommon when the item number in the dimension is lower than 10 and in accordance with this statement Vaske (2008) mentioned that finding Cronbach alpha between 0.65 and 0.70 could be acceptable in such situations (as cited in. Shelby, 2011). Furthermore, there was no item in both dimensions which improves Cronbach alpha value when item is deleted. In accordance with these explanations, no item was deleted from the scale and interpreted as no problem in terms of reliability.

4.1.2.2. Confirmatory Factor Analysis Results of OMESS

Similar process with OMEBS was followed for OBMISS and data obtained from 299 prospective elementary mathematics teachers was analyzed with confirmatory factor analysis techniques in order to confirm factor model. OMESS has eight items and composed of one dimension named as *perceived self-efficacy in using origami in mathematics education.*

In the first analysis, RMSEA value is found higher than 0.10 which is interpreted as some modifications are required for the tested model and after two modifications RMSEA value is calculated as 0.068 which can be accepted as sufficient (Steiger, 1990, as cited in. Kelloway, 1998). Modifications were made between "How well do you feel to explain the place of origami in the national elementary mathematics curriculum?" and "How well do you feel to choose appropriate origami model in order to gain objectives in the elementary mathematics curriculum?"; moreover between "How well do you feel to make abstract mathematical concepts more concrete by using origami activities?" and "How well do you feel to find solutions to the problems of students while relating origami activity to mathematics topics?".

Hypothesized factor model of the OMESS with modifications can be seen in Figure 4.

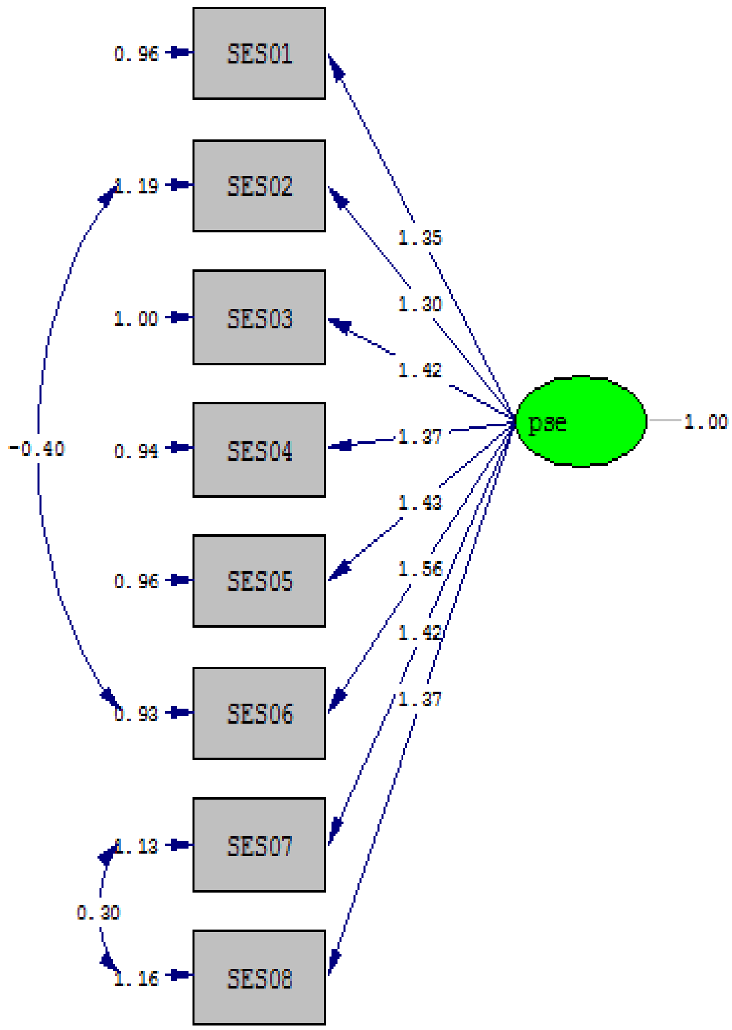

Figure 4. Hypothesized Model and Confirmatory Factor Analysis Results of OMESS

In addition to the RMSEA value, some other fit indexes offered by LISREL 8.8 were investigated. Comparative Fit Index (CFI) and Normed Fıt Index (NFI) were both calculated as 0.99 and Goodness of Fıt Index (GFI) was calculated as 0.97. Furthermore, Normed Chi Square (NC) was calculated as 2.37 (40.22/17).

Cronbach alpha coefficient was calculated for the only dimension of OMESS and found to be 0.94 and interpreted as quite high (Pallant, 2007). Furthermore, deleting any of the items did not improve Cronbach alpha value which can be interpreted as all the items have a positive effect on the internal consistency.

4.2. Descriptive Analysis of OMEBS and OMESS

Factor model of OMEBS and OMESS were established via exploratory factor analysis with the data obtained from pilot study and then, these models were confirmed via confirmatory factory analysis with the data obtained from main study. Latest version of OBMEBS and OMESS can be seen in Appendix C. After establishing and confirming factor models, data obtained from main study was analyzed with descriptive statistics techniques in order to determine prospective elementary mathematics teachers' beliefs and perceived self-efficacy beliefs towards using origami in mathematics education. Results of these analyses will be given in two subheadings as: Beliefs of Turkish prospective elementary mathematics teachers' towards using origami in mathematics education and perceived self-efficacy belief levels of Turkish prospective elementary mathematics teachers in using origami in mathematics education.

4.2.1. Beliefs of Turkish Prospective Elementary Mathematics Teachers towards Using Origami in Mathematics Education

According to the exploratory and confirmatory factor analysis results, it was decided that OMEBS composed of two dimensions which are *benefits of origami in mathematics education* and *limitations of using origami in mathematics education*. In order to have a better understanding about Turkish prospective elementary mathematics teachers' beliefs towards using origami in mathematics education descriptive statistics were calculated for each dimension and will be explained in the following two sections.

4.2.1.1. Beliefs regarding Benefits of Origami When Used in Mathematics Education

In OMEBS, there are 19 items which were loaded in the *benefits of origami in mathematics education* dimension. These items are related with the benefits of origami when used in mathematics education. The mean score of these 19 items was calculated as 5.22 out of 6 which can be interpreted as quite high. This high mean score indicates that Turkish prospective elementary mathematics teachers, who have origami based mathematics instruction lesson experience, believe that origami is a beneficial instructional tool to be used in mathematics education. To have a better insight about in which context origami can be beneficial, Table 11 indicates mean scores of each item in the first dimension.

Table 11

Mean Scores and Standard Deviations of Items in the First Dimension of OMEBS

Item in the OMEBS	Mean	SD
Origami is beneficial to make some abstract mathematical concepts more concrete.	5.51	.82
Origami activities help to reduce mathematics anxiety of students.	5.01	.98
Origami activities help students to improve their mathematical problem solving ability.	4.98	.90
Using origami activities in mathematics lessons makes lessons more amusing.	5.43	.85
Origami enables elementary students to see the relationship between mathematics and art.	5.23	.96
Origami make easy to teach geometrical concepts.	5.33	.87
Mathematics lessons in which origami activities are used took attention by students.	5.46	.76
Origami helps students to improve their proving ability.	4.98	1.00
Origami helps to improve spatial ability of students.	5.25	.77
Children who made Origami in preschool time learn geometry subjects easily in later years.	5.11	.87
Origami is an instruction tool which can be used in mathematics lessons.	5.00	.88
Origami is appropriate for modern learning theories in mathematics since it is an activity based approach.	5.24	.75
Origami enables effective learning in mathematics since it is a visual, audible and physical activity.	5.19	.88
Using origami activities in mathematics education enables students to actively attend to lesson.	5.27	.82
Using mathematical terms during origami activity helps to improve mathematical language of students.	5.22	.89
Modular origami is an activity which promote group working in mathematics lessons.	5.16	.93
Origami makes easy students learning of some mathematical concepts.	5.10	.91
Motivation of students increases to mathematics lessons in which origami activities are used.	5.26	.83
Origami helps students to understand the relationship between geometrical shapes.	5.40	.73

For each question in the dimension, minimum value was calculated as 1 while maximum value calculated as 6. Therefore, it is possible to say that, for each item there are both positive and negative beliefs regarding the benefits of origami in mathematics education. However, mean scores on items in the first dimension show that prospective teachers generally have very positive beliefs regarding the benefits of origami when used in mathematics education. Almost all items have mean score higher than five out of possible six which indicate that prospective teachers believe that origami is mathematically beneficial activity. Making mathematical concepts more concrete, making mathematics lessons more amusing, helping to understand geometry topics and relationship between geometrical shapes seem to be the most prominent benefits of origami according to the answers of prospective teachers. Furthermore, prospective teachers also strongly believe that origami is beneficial to improve spatial reasoning skills, mathematical language of students. With respect to other items, improving mathematical problem solving ability and proving ability had lower mean scores but it should be noted that these two items' mean score is 4.98 which is still quite high. In addition to the mathematical benefits of origami, prospective teachers also believe that origami is also beneficial as an instructional method by stating it enables active learning, effective learning while also being appropriate for mathematics lessons and contemporary learning theories.

In summary, although there are contradictory beliefs in the sample for each question, mean scores of each item show that prospective elementary mathematics teachers strongly believe that origami has various mathematical benefits and suitable to be used in mathematics education.

4.2.1.2. Limitation Beliefs in Using Origami in Mathematics Education

In OMEBS, there are 7 items about the possible *limitations of using origami in mathematics education*. Similar to the items in the first dimension, the maximum value calculated as 6 while minimum score calculated as 1 for each item in the second dimension. In the 6 point Likert type 3 corresponds to little disagree and four of the seven items have lower mean scores than 3 which means that most of the prospective teachers don't believe that origami is just a game, origami is merely suitable for geometry topics in mathematics education and it is easy to forget what you learn in origami blended mathematics lesson. However, three of the seven items which are: "It takes long time to use origami activities in mathematics lessons (M=3.97)", "It is difficult to plan a mathematics lesson in which origami activities will be used (M=3.72)", and "Origami cannot be used for mathematics lessons in crowded classes (M=3.41)" have higher mean scores than 3. Therefore, it is possible to say that most prominent beliefs regarding the limitation of using origami in mathematics education are taking long time, difficult planning process and being inappropriate to be used in crowded classes according to the answers of Turkish elementary prospective teachers.

In general, items in the second dimension which are related to possible limitations of using origami in mathematics education have lower mean scores when compared with the items related to benefits of origami. Detailed information for mean and standard deviation distribution for each item is presented in Table 12.

Table 12
Mean Scores and Standard Deviations of Items in the Second Dimension of OMEBS

Item in the OMEBS	Mean	SD
It takes long time to use origami activities in mathematics lessons.	3.97	1.13
Origami cannot be used in mathematics topics except geometry.	2.53	1.27
It is difficult to plan a mathematics lesson in which origami activities will be used.	3.72	1.23
A mathematics lesson in which origami activities are used is just a game for students.	2.60	1.24
Origami cannot be used for mathematics lessons in crowded classes.	3.41	1.22
It is difficult to integrate origami into the mathematics education.	2.93	1.25
It is easy to forget learnings of mathematics lesson in which origami activities are used.	2.02	1.17

4.2.2. Perceived Self-Efficacy Belief Levels of Turkish Prospective Elementary Mathematics Teachers in Using Origami in Mathematics Education

In OMESS, there are eight questions to measure perceived self-efficacy beliefs towards using origami in mathematics lessons. Descriptive statistics were used in order to analyze answers of 299 prospective elementary mathematics teachers who have lesson experience about origami based mathematics instruction. The mean score of total eight items is calculated as 5.58 out of 9 which can be interpreted as little more than moderate level. Descriptive statistics for each item of the scale are given in Table 13.

Table 13
Item Mean and Standard Deviation Distribution of OMESS

How well do you feel…	Mean	SD
to use origami effectively in mathematics lessons during your teaching years?	5.37	1.68
to explain the place of origami in the national elementary mathematics curriculum?	5.32	1.71
to plan a mathematics lesson in which origami activities will be used?	5.08	1.74
to give example about how origami can be used in mathematics education?	5.74	1.69
to use mathematical language during origami activities?	5.73	1.74
to choose appropriate origami model in order to gain objectives in the elementary mathematics curriculum?	5.61	1.85
to make abstract mathematical concepts more concrete by using origami activities?	6.15	1.78
to find solutions to the problems of students while relating origami activity to mathematics topics?	5.63	1.75

In eight items the item of “How well do you feel to make abstract mathematical concepts more concrete by using origami activities?” have the highest mean score as 6.15 with the standard deviation of 1.78 while the item of “How well do you feel to plan a mathematics lesson in which origami activities will be used?” have the lowest mean score as 5.08 with the standard deviation of 1.74. Although, there is no such a big mean difference between the highest mean score and the lowest mean score, it can be concluded that prospective teachers see themselves most efficient on making abstract mathematical concepts more concrete via origami while least efficient on planning a mathematics lesson in which origami activities are used. Furthermore, prospective teachers see themselves moderately efficient on effectively using origami in mathematics lessons, finding solutions to problems occurred while using origami activities in mathematics lessons, choosing suitable origami models in accordance with objectives.

In general, items in the OMESS which aim to measure prospective teachers' perceived self-efficacy belief levels in using origami in mathematics education have mean scores around five which is the middle level of 9 point Likert type scale. Therefore, it can be concluded that Turkish prospective elementary mathematics teachers have moderate perceived self-efficacy belief levels on planning and effectively administering origami activities for mathematics lessons.

4.3. Gender Differences in Prospective Elementary Mathematics Teachers' Beliefs and Perceived Self-Efficacy Belief Levels in Using Origami in Mathematics Education

In the current study, independent sample t-test was used in order to investigate gender differences in prospective elementary mathematics teachers' beliefs and perceived self-efficacy belief levels in using origami in mathematics education. Assumptions for the independent sample t-test, inferential statistic results are given in the following sections.

4.3.1. Assumptions for the Independent Sample t-test

Before implementing and interpreting independent sample t-test for the data obtained from OMEBS and OMESS, assumptions for the independent sample t-test were investigated.

From the viewpoint of Pallant (2007), there are five main assumptions of independent sample t-test which are level of measurement, random sampling, independence of observations, normal distribution and lastly homogeneity of variance. In this section, these five assumptions were investigated in order to run independent sample t-test for the data obtained from OMEBS and OMESS.

As a first assumption, level of measurement was investigated. In order to assure this assumption, dependent variable must be measured at the internal or ratio level and must be continuous (Pallant, 2007). In the current study, to be able to identify gender differences in beliefs and perceived self-efficacy belief levels in using origami in mathematics education, mean scores obtained from OMEBS and OMESS were used as dependent variables which are continuous not categorical. Therefore, it can be concluded that level of measurement assumption is assured.

Independent sample t-test assumed that data obtained from the randomly selected sample but it is generally difficult to choose random sampling methods in most of the researches (Pallant, 2007). In accordance with this statement, it is assumed that choosing purposive sampling method in accordance with the purposes of the study would not cause to major problems.

Independence of observations is another important assumption of independent sample t-test and means that participants of the study would not influenced by any other factors and must be independent of each other (Pallant, 2007). In the data collection process no events that may influence participants' responses were observed and so, it is assumed that this assumption is not violated.

In order to assure normality assumption, each group must have normally distributed scores on the dependent variable (Pallant, 2007). In the current study, there are two groups for the independent sample t-test which are females and males. Skewness and kurtosis values for these groups on the dependent variables which are mean score of OMESS and OMEBS are given with the Table 14. Furthermore, histograms for each group are given in Appendix D.

Table 14
Skewness and Kurtosis Values for OMEBS and OMESS Mean Scores Regarding Gender

Groups	OMEBS Mean Scores			OMESS Mean Scores		
	Skewness	Kurtosis	N	Skewness	Kurtosis	N
Female	- 1.81	7.94	211	- .36	.33	211
Male	- 1.40	3.49	88	- .58	.04	86

As can be seen in Table 12, mean scores obtained from OMESS, normally distributed for both of the groups since skewness and kurtosis values were calculated between -2 and 2 (Pallant, 2007). However, mean scores obtained from OMEBS did not normally distributed for the groups since kurtosis values are higher than 2. In such a case, violation of this assumption did not bring about major problems when the sample size is larger than 30 (Pallant, 2007). In accordance with this statement, it is assumed that high kurtosis values for OMEBS mean scores of female and male participants would not baffle to run independent sample t-test since the number of the both groups is quite higher than 30.

As a last assumption, homogeneity of variances is investigated via Levene’s test for equality of variances. As can be seen in Table 15, Levene's test was found as non-significant (›.05) for the mean scores obtained from OMEBS and OMESS and interpreted as the groups of female and males have equal variances (Pallant, 2007).

Table 15
Levene's Test for Equality of Variances Results

	Levene's Test for Equality of Variances	
	F	Sig.
OMEBS mean scores	1.71	.19
OMESS mean scores	1.06	.31

In brief, five assumptions for the independent sample t-test were assured and it was decided as there is no problem to run independent sample t-test in order to investigate gender differences in beliefs and perceived self-efficacy beliefs of prospective elementary mathematics teachers towards using origami in mathematics education. Results of these analyses are given in the following sections.

4.3.2. Gender Differences in Beliefs towards Using Origami in Mathematics Education

In accordance with the fourth research question of the study, gender differences in the prospective elementary mathematics teachers' beliefs towards using origami in mathematics education were investigated in the current study.

To be able to answer this research question, mean difference between female and male prospective elementary mathematics teachers' answers to OMEBS were investigated via independent sample t-test.

According to the independent sample t-test results that given in Table 16, there was a significant mean difference between female and male teacher candidates in beliefs towards using origami in mathematics education (t(297)= 5.60, p= .00). Therefore, there is enough evidence to conclude that female teacher candidates (M=4.99, SD=.51) have significantly higher beliefs in using origami in mathematics education than male teacher candidates (M=4.61, SD=.61).

Table 16
Independent Sample t-test Results for Female and Male Responses to OMEBS

T-test for Equality of Means						
t	df	Sig.(2 tailed)	Mean Difference	Std. Error Difference	%95 Confidence Interval of Difference	
					Lower	Upper
5.60	297	.00	.38	.06	.25	.52

Eta squared calculated as .10 and interpreted as the magnitude of the differences in OMEBS means is moderate (Cohen, 1988). Calculating eta squared as .10 indicates that 10 percent of the variance in beliefs in using origami in mathematics education is explained by gender (Pallant, 2007).

To sum up, mean score of female prospective elementary mathematics teachers' responses for OMEBS is calculated as 4.99 with the standard deviation of .51 while mean score of male prospective elementary mathematics teachers' responses for OMEBS is calculated as 4.61 with the standard deviation of .61. Although, both of these mean values can be interpreted as high, independent sample t-test revealed that there is a statistically significant mean difference between female and male prospective elementary mathematics teachers in favor of females. In other words, female prospective teachers hold more positive beliefs towards using origami in mathematics education than male prospective teachers. Therefore, it is possible to say that female prospective teachers see origami more beneficial in mathematics education when compared with male prospective teachers.

4.3.3. Gender Differences in Perceived Self-Efficacy Belief Levels in Using Origami in Mathematics Education

In accordance with the last research question of the study, gender differences in prospective elementary mathematics teachers' perceived self-efficacy beliefs in using origami in mathematics education were investigated in this study.

In order to answers this question, mean difference between female and male participants' answers to OMESS were investigated via independent sample t-test.

Table 17
Independent Sample t-test Results for Female and Male Responses to OMESS

T-test for Equality of Means						
t	df	Sig.(2 tailed)	Mean Difference	Std. Error Difference	%95 Confidence Interval of Difference	
					Lower	Upper
2.77	295	.01	.51	.18	.15	.87

As given in Table 17, independent sample t-test results indicated that there is a significant mean difference between female and male teacher candidates in perceived self-efficacy belief levels in using origami in mathematics education ($t(295)=2.77$, $p= .01$). In accordance with this result, it is possible say that there is enough evidence to conclude that perceived self-efficacy belief level of female prospective elementary mathematics teachers ($M=5.72$, $SD=1.39$) is significantly higher than male prospective elementary mathematics teachers' perceived self-efficacy belief levels (M=5.22, SD=1.55).

In order to determine effect size, eta squared calculated as .03 and interpreted as small in degree (Cohen, 1988). Calculating eta squared as .03 indicates that 3 percent of the variance in perceived self-efficacy belief levels in using origami in mathematics education is explained by gender (Pallant, 2007).

In brief, mean score of female prospective elementary mathematics teachers' responses for OMESS was calculated as 5.72 with the standard deviation of 1.39 while mean score of male prospective elementary mathematics teachers' responses for OMESS was calculated as 5.22 with the standard deviation of 1.55. Both of the mean values can be interpreted as little higher than the moderate level but mean difference between female and male participants was found as statistically significant as the result of independent sample t-test. Therefore it is possible to say that, female prospective teachers feel more efficient to use origami in mathematics education than male prospective teachers. In other words, from the viewpoint of Bandura (2006), female prospective teachers would probably be more motivated and decisive to use origami in mathematics lessons when compared with male prospective teachers. However, it should be noted that the calculated eta squared indicates that the magnitude of the differences in the means is small (eta squared= .03).

4.4. Summary of the Findings of the Study

The current study aims to develop valid and reliable scales in order to measure beliefs and perceived self-efficacy beliefs in using origami in mathematics education. Furthermore, it is also aimed to investigate beliefs and perceived self-efficacy beliefs of prospective elementary mathematics teachers towards using origami in mathematics education and whether these beliefs and perceived self-efficacy beliefs differ by gender.

In accordance with the first purpose, OMEBS and OMESS were developed and exploratory factor analysis was conducted with the data obtained from 143 prospective elementary mathematics teachers who have origami lesson experience. According to the exploratory factor analysis results, OMEBS comprised of 26 items with two dimensions named: *benefits of origami in mathematics education* and *limitations of using origami in mathematics education*. Furthermore, OMESS composed of one dimension with eight items. In order to confirm these factor structures, confirmatory factor analysis was applied with the data obtained from 299 prospective elementary mathematics teachers who have elective origami lesson experience. According to confirmatory factor analysis results, RMSEA was found as 0.91, CFI and GFI values were both found as 0.90 for OMEBS. For OMESS, RMSEA was found as 0.068, CFI and GFI values were both found as 0.99. These values for both of the scales accepted as an evidence to confirm the model obtained in exploratory factor analysis. In addition to the validity evidences, Cronbach alpha values were calculated for each dimension of the scales in order to check the reliability of the data obtained from these newly developed scales. Cronbach alpha values were calculated as 0.95 and 0.66 respectively for *benefits of origami in mathematics education* and *limitations of using origami in mathematics education* dimensions of OMEBS. Furthermore, it was calculated as 0.94 for *perceived self-*

efficacy in using origami in mathematics education dimension of OMESS. These values were interpreted as sufficient for the reliability as explained above in detail.

In order to establish prospective teachers' beliefs and perceived self-efficacy beliefs towards using origami in mathematics education, descriptive statistics used for the data obtained from main study. According to descriptive analysis results, the mean score of items in the *benefits of origami in mathematics education* was found as 5.22 and interpreted as most of the participants thought origami can be beneficial in mathematics education since it has various mathematical characteristics. Furthermore, the mean score of the items in *limitations of using origami in mathematics education* dimension of OMEBS was calculated as 3.03 which refer to little disagree with the statements in this dimension. Therefore, it can be concluded that prospective teachers thought origami does not have too much limitations when used in mathematics lessons as an instructional method. However, according to participants' answers it should be noted that, the most prominent limitation beliefs about origami is taking long time to use, being inadequate to be used in crowded classes and being difficult to plan how to use it in mathematics lessons. For OMESS, mean score of eight items in the *perceived self-efficacy beliefs in using origami in mathematics education* dimension was calculated as 5.58 and interpreted as prospective elementary mathematics teachers have little more than moderate perceived self-efficacy belief level in using origami in mathematics education.

As a last purpose, difference between female and male prospective teachers on beliefs and perceived self-efficacy beliefs towards using origami in mathematics education was investigated via independent sample t-test. According test results, it was found that female prospective teachers have higher beliefs and perceived self-efficacy beliefs towards using origami in mathematics education when compared with male prospective teachers. Therefore, it was concluded female prospective teachers tend to use origami in mathematics lessons more than male prospective teachers since beliefs and perceived self-efficacy beliefs are accepted as indicator of behavior as explained in the literature review part. The effect size was found as moderate for the difference in OMEBS and small for the difference in OMESS.

CHAPTER 5

DISCUSSION, IMPLICATIONS AND RECOMMENDATIONS

The current study aimed to develop valid and reliable scales in order to measure beliefs and perceived self-efficacy beliefs towards using origami in mathematics education. Furthermore, it also aimed to identify, via these scales, prospective elementary mathematics teachers' beliefs and perceived self-efficacy beliefs in using origami in mathematics education. As a final purpose, gender differences in beliefs and perceived self-efficacy beliefs towards using origami in mathematics education are also investigated in the current study. In this chapter, findings related with these purposes are discussed; implications and recommendations for educational practices are evaluated.

5.1. Validity and Reliability of the Data Collection Instruments

In order to interpret the findings of a research study accurately, the very first step is accepted as having valid and reliable instruments (Fraenkel & Wallen, 2006). In accordance with this statement, validity and reliability evidences for OMEBS and OMESS are discussed in this part.

5.1.1. Discussion on the Validity and Reliability Evidences of OMEBS

While developing the items in OMEBS, research studies on origami, beliefs and self-efficacy beliefs were investigated in detail and the experiences of the researcher of the current study from an elective origami course for prospective elementary mathematics teachers were taken into consideration. After this process, the items of the scale were evaluated by two experts from educational measurement and mathematics education departments and their suggestions were also taken into consideration. Subsequently, the items were interpreted by three prospective teachers who had taken a course on origami in order to make the items of the scale more comprehensible to the participants of the study. In the final step, the items were evaluated by three experts from mathematics education and science education departments. One of the experts from the mathematics education departments was instructing in an origami course for prospective mathematics teachers and the other two experts had conducted numerous studies on beliefs and self-efficacy beliefs of prospective teachers. All of these steps can be interpreted as powerful indicators of construct validity of the scales (Crocker & Algina, 1986).

There is no scale in terms of beliefs in the accessible origami related literature; moreover, there is no widely accepted theory of origami based mathematics instruction. In such a situation, conducting exploratory factor analysis to establish a factorial structure of the scale during the pilot study and then testing this established model through confirmatory factor analysis are recommended (Büyüköztürk, 2002; Çokluk, Şekercioğlu and Büyüköztürk, 2010; Matsunaga, 2010; Pallant, 2007). Therefore, data obtained from the pilot study of OMEBS underwent exploratory factor analysis via PASW 18, and data obtained from the main study were analyzed using confirmatory factor analysis via LISREL 8.8. According to the exploratory factor analysis results, it was decided that OMEBS was composed of two dimensions called *benefits of origami in mathematics education* and *limitations of using origami in mathematics education*. These factors explain 46 percent of the total variance and this value can be accepted as the power of the established factor structure of the scale (Çokluk, Şekercioğlu and Büyüköztürk, 2010). According to Stevens (2002), factor loading should be higher than 0.30 for each item and there should not be cross loading for any of the items in the scale. For the items in the OMEBS, there was no cross loading in the exploratory factor analysis and all the items had factor loadings higher than 0.30. Therefore, it can be concluded that all the items had sufficiently powerful relationships with the dimension they loaded on (Çokluk, Şekercioğlu and Büyüköztürk, 2010).

After the factor structure of OMEBS was established, confirmatory factor analysis was conducted with the data obtained from the main study. In accordance with the findings of the exploratory factor analysis, the model with two dimensions named as *benefits of origami in mathematics education* (17 items) and *limitations of using origami in mathematics education* (9 items) was tested with confirmatory factor analysis. In the confirmatory factor analysis, RMSEA was found to be 0.091 after two modifications and this value can be accepted as one of the evidences of a good fit of the model (Steiger, 1990, as cited in Kelloway, 1998). It is widely accepted that CFI and GFI values should be close to one in well-fitted models (Çokluk, Şekercioğlu and Büyüköztürk, 2010). These values were both calculated as 0.90 for the tested model of OMEBS and can be accepted as an indicator of a good fit (Hu & Bentler, 1999; Kelloway, 1998). Furthermore, calculating Normed Chi Square as 3.45, which is lower than five, can be interpreted as the hypothesized model of OMEBS fitting the data well (Kelloway, 1998). From the viewpoint of Matsunaga (2010), there is no widely accepted fit index for the confirmatory factor analysis, and evaluating the fitness of the model with more fit indices is important in order to make better decisions. Therefore, the hypothesized model of OMEBS were interpreted with different fit indices and according to the interpretations based on these indices, it was decided that the hypothesized factor model for OMEBS explained the underlying structure of the scale at a good degree.

Establishing the factor structure of OMEBS and then confirming this structure with confirmatory factor analysis can be interpreted as a strong evidence for the construct validity of the scale (Crocker & Algina, 1986).

After establishing the factor pattern of OMEBS, the internal consistency of the participants' answers to the scale were investigated by calculating Cronbach alpha coefficients. For the data obtained from the main study, the Cronbach alpha was found to be 0.95 and 0.66 respectively for the dimensions of *benefits of origami in mathematics education* and *limitations of using origami in mathematics education*. The value of 0.95 can be interpreted as a high internal consistency for the dimension of *benefits of origami in mathematics education* (Pallant, 2007). Although the value of 0.66 for the dimension of *limitations of using origami in mathematics education* can be interpreted as low at first, when the item number in the scale and the measured construct were taken into consideration, it was accepted as sufficient for the internal consistency (Vaske, 2008, as cited in Shellby, 2011).

To sum up, validity and reliability evidences for OMEBS are explained in this part of the study. However, further validity evidences with different samples are suggested in order to gain a better idea on the validity of this newly developed scale.

5.1.2. Discussion on the Validity and Reliability Evidences of OMESS

The items in OMESS were developed in a similar way to the item development process followed in the construction of OMEBS. Eight items in the scale were firstly interpreted by two experts and then, interviews with three teacher candidates were conducted, and as a final step, the last versions of these items were evaluated by three experts. Therefore, the item development process of the OMESS can be interpreted as an evidence for the construct validity of the scale (Crocker & Algina, 1986).

According to the exploratory factor analysis, which was conducted with the data obtained from pilot study, it was decided that one-factor structure was appropriate for OMESS. This factor was named as *perceived self-efficacy in using origami in mathematics education* and explains 73 percent of the total variance. This value can indicate that the established factor pattern is quite powerful since explaining 30 percent of the total variance is accepted as sufficient for scales with one dimension (Çokluk, Şekercioğlu and Büyüköztürk, 2010). Furthermore, all the items have higher factor loadings than 0.30, which shows that all items measure what the dimension aims to measure (Çokluk, Şekercioğlu and Büyüköztürk, 2010).

The hypothesized factor model for OMESS was tested with the data obtained from the main study via confirmatory factor analysis. The RMSEA value was calculated as 0.068 and finding RMSEA value lower than 0.10 was accepted as an evidence of a good fit (Steiger, 1990, as cited in Kelloway, 1998). CFI and NFI values were both calculated as 0.99; these indices can indicate that the tested model fits the data quite well (Hu & Bentler, 1999). Furthermore, the NC value which was calculated as 2.37 can be interpreted as an indicator of a perfect fit (Kline, 2005).

As a result of exploratory and confirmatory factor analyses, OMESS was composed of one dimension with eight items called *perceived self-efficacy in using origami in mathematics education.* In order to investigate the internal consistency of OMESS, the Cronbach alpha coefficient was calculated for the single dimension of the scale. Finding Cronbach alpha coefficient as 0.95 was interpreted as quite a high internal consistency (Pallant, 2007).

In this part of the study, some validity and reliability analyses for OMESS were interpreted. Although various validity and reliability evidences for OMESS were presented in this part, further validity evidences are recommended for the scale.

5.2. Beliefs and Perceived Self-Efficacy Beliefs of Prospective Elementary Mathematics Teachers in Using Origami in Mathematics Education

In this part of the study, discussion on the findings regarding prospective elementary mathematics teachers' beliefs and perceived self-efficacy beliefs towards using origami in mathematics education is presented under two subheadings.

5.2.1. Beliefs of Prospective Teachers in Using Origami in Mathematics Education

According to the descriptive analyses results gained through OMEBS, participants of the current study were found to have consistent beliefs with the findings of research studies in the literature. For instance, prospective teachers strongly believed that origami makes some abstract mathematical concepts more concrete, which is commonly mentioned in origami related literature (e.g., Georgeson, 2011; Olson, 1989). Furthermore, they believe that origami is quite an effective way of teaching geometry, which is also mentioned in various studies in the literature (e.g., Cagle, 2009; Canadas et al. 2010; Golan & Jackson, 2010). The benefits of origami in improving students' mathematical language also received quite a high mean score, which is generally accepted as one of the major benefits of using origami in mathematics education in related literature (e.g., Cipoletti & Wilson, 2004; Hartzler, 2003; Robichaux & Rodrigue, 2003).

In the study of Çakmak (2009), almost all elementary students who had participated in origami based mathematics lessons described origami as an amusing and motivating activity. In consistency with this finding, the mean scores of some items in OMEBS indicated that teacher candidates saw origami as a teaching activity that was amusing and attractive for students and believed that it helped students to actively attend mathematics lessons. Such kind of a belief might derive from being actively involved in the paper folding process and enabling students to construct their own origami model. According to the descriptive analysis results of the items in the dimension entitled *limitations of using origami in mathematics education* of

OMEBS, it can be concluded that prospective teachers do not interpret origami as an instruction method having various limitations. From the viewpoint of Golan and Jackson (2010), receiving education in how to use origami effectively in mathematics education is crucial. The participants of the current study had taken a course in how to use origami in mathematics education and with the effects of this experience; they knew how to overcome some problems which may occur while using origami activities in mathematics lessons. This characteristic of the participants might have affected their responses on the items related to possible limitations of origami when used in mathematics education and thus, they might not have believed that origami has various limitations to be used in mathematics lessons.

When the descriptive analysis results for the OMEBS are interpreted as a whole, it is possible to conclude that prospective elementary mathematics teachers believe that origami is a beneficial instructional tool to be used in mathematics lessons. These results can be interpreted as being consistent with the findings of Kayan (2011). In the study of Kayan (2011) it was found that Turkish prospective elementary mathematics teachers hold some constructivist mathematics teaching beliefs with the effect of teacher education programs. Furthermore, it is mentioned that prospective teachers support using activities that make mathematical concepts more concrete in mathematics lessons in order to gain positive attitudes towards mathematics lessons and attend lessons more actively. From the viewpoint of Sze (2005a), origami can be used as an instructional tool in accordance with the constructivist learning theory since it is based on student-centered learning besides being appropriate in addressing multiple intelligences. Prospective teachers might have positive beliefs towards using origami in mathematics education since the teacher education programs in Turkey are based on activity based learning, and they might interpret the use of origami appropriate in constructivist learning environments as an activity based approach.

5.2.2. Perceived Self-Efficacy Beliefs of Prospective Teachers in Using Origami in Mathematics Education

In the current study, it was found that prospective elementary mathematics teachers' perceived self-efficacy belief levels in using origami in mathematics education were little higher than moderate level. In relevant studies conducted with Turkish prospective teachers, Çakıroğlu and Işıksal (2009) found that mathematics teacher candidates had high mathematical self-efficacy beliefs but when the issue is teaching mathematics, Mehmetlioğlu (2010) found that prospective teachers' readiness level for the mathematics teaching profession is at middle level. The current study yielded results similar to those found in the study of Mehmetlioğlu (2010) and showed that prospective teachers did not feel confident enough to effectively use origami as a teaching tool for mathematics lessons.

Mastery experiences are described as crucial sources in perceived self-efficacy beliefs (Bandura, 1977). This view is also supported in the teaching field with different research studies. For instance, in the studies of Brand and Wilkins (2007), and Swars et al. (2007) it was found that methodology courses and teaching practices had positive impacts on prospective teachers' teaching efficacy. When the issue is using origami activities in mathematics lessons, elective courses on origami can be accepted as a type of methodology course since these courses aim to instruct effective ways of teaching with origami. Participants of the current study had taken an elective origami lesson but their efficacy levels in using origami as a mathematics teaching tool was not at a high level. Supported with the studies of Brand and Wilkins (2007), and Swars et al. (2007), teaching practices in addition to methodology courses are important in gaining efficacy. Therefore, if prospective teachers have the opportunity to use origami in other courses of teacher education programs, such as teaching experience courses; it may lead to improvement in their efficacy belief levels in using origami in mathematics education.

To sum up, it was observed in the current study that prospective elementary mathematics teachers had a slightly higher efficacy level than moderate efficacy in using origami in mathematics education. Reorganizing elective origami courses by enabling prospective teachers to use origami in real teaching environments might improve their perceived self-efficacy beliefs in using origami in mathematics education. For instance, enabling prospective teachers to use origami in elementary schools throughout elective origami courses would help to practice what they had learned in these elective courses. Therefore, it might lead to an improvement in their efficacy levels to use origami in mathematics education.

5.3. Discussion on Findings related to Gender Differences

In the current study, it was found that female prospective teachers had significantly higher mean scores in beliefs towards using origami in mathematics education than those of male prospective teachers. Furthermore, effect size was calculated as moderate. In the literature, Li (1999) examined studies related to gender differences in teachers' beliefs and concluded that female and male teachers held similar mathematics teaching beliefs in general. This view was also supported by some national researchers. For instance, Duatepe-Paksu (2008) found that gender is not influential in mathematical beliefs of prospective teachers and similarly, Kayan (2011) found that the difference between male and female prospective teachers' mathematical beliefs is quite low. Furthermore, Bulut and Baydar (2003) investigated prospective teachers' mathematics teaching beliefs and found that there is no significant difference in mathematics teaching beliefs regarding gender. Contradictory to these studies, the current study found that the difference between female and male prospective teachers' beliefs towards using origami in mathematics education is moderate in degree in favor of females. In the education field, moderate effect size can be accepted as an important difference (Tabahnick & Fidell, 2001). According to Li (1999), female teachers prefer student-centered and activity based teaching environments more than their male counterparts. Therefore, origami, which could be described as a student-centered and activity-based approach (MoNE, 2009b), might draw more attention by female prospective teachers and, as a result, they might have higher mean beliefs in using origami in mathematics education. Furthermore, as a result of social environment, females are more likely to do activities which require the use of fine motor skills and, thus, they might be more familiar with paper folding activities when compared with males. Therefore, in the early levels of education, learning environments in which fine motor skills are used should be created for males. If males engage in paper folding activities earlier they might hold similar beliefs with females in later years.

Similar to the beliefs in using origami in mathematics education, female prospective teachers showed significantly higher efficacy levels than male prospective teachers in origami-based mathematics instruction. However, a small effect size was calculated. In relevant studies, Işıksal (2005) found that there was no significant effect of gender on the mathematical self-efficacy beliefs of prospective elementary mathematics teachers and, similarly, Işıksal and Çakıroğlu (2005) did not find any significant difference between female and male teacher candidates' mathematics teaching efficacy. Furthermore, in the study of Mehmetlioğlu (2010), it was seen that there was no significant difference between female and male prospective teachers in terms of mathematics teaching readiness. In the current study contradictory results with these studies were found, which might be a result of female prospective teachers' highly positive beliefs towards using origami in mathematics education as stated above. Apart from the origami perspective, teaching is accepted as a female domain in Turkey (Işıksal, 2005) and this situation may have an impact on the difference between female and male prospective teachers' perceived self-efficacy beliefs towards using origami in mathematics education. Therefore, female teacher candidates might feel more efficient in using origami in mathematics education.

Fennema (2002) mentioned that investigating gender differences from different perspectives would be beneficial in order to understand possible differences in mathematics education. In accordance with this view it was thought that investigating gender differences in using origami in mathematics education would be beneficial since no studies investigating these issues could be reached in the accessible literature. According to the results of the current study, it was seen that female prospective elementary mathematics teachers had significantly higher beliefs and perceived self-efficacy beliefs in using origami in mathematics education than male prospective elementary mathematics teachers. This difference might be a result of male teacher candidates' lack of experience in activities that require the use of fine motor skills and, thus, male teacher candidates could interpret the use of origami activities in mathematics education as a female domain. In order to eliminate this difference, males should be more familiar with these kinds of activities; hence, paper folding activities should be used in learning environments from the beginning years of education.

5.4. Implications for Mathematics Education

In the current study, prospective elementary mathematics teachers' origami related beliefs and perceived self-efficacy beliefs were investigated and based on the results of this study, possible implications for mathematics education are presented in this part of the study.

In the national mathematics curriculum, origami is interpreted as an important teaching tool for mathematics education and some origami blended lesson activities are presented in the program. Furthermore, origami takes place in mathematics education textbooks. Although origami has a place in the national mathematics education, there is not enough resources published in Turkish for origami based mathematics instruction. This information can be inferred from the answers prospective teachers gave to the question about their origami related experience; only 16 percent of the participants reported having some kind of experience with publications on origami. In order to increase this percentage, more publications on how to use origami in mathematics education should be made, and these resources should be accessible to prospective and in-service mathematics teachers.

In the current study, prospective teachers who took origami lessons constituted the sample group. However, the number of universities which offer elective origami courses for prospective elementary mathematics teachers is extremely low. For this reason, improving the number of origami courses in universities is crucial in order to equip prospective teachers with in-depth knowledge on how to use origami as a teaching tool. Furthermore, in-service training programs and seminars would be beneficial to enhance in-service mathematics teachers' knowledge on origami based mathematics instruction. It is crucial to realize that the first step towards the effective use of origami in mathematics education is to have well-educated teachers in the use of origami as an educational tool (Golan & Jackson, 2010).

According to descriptive analysis results obtained from OMEBS, it was observed that prospective teachers have highly positive beliefs towards using origami in mathematics education. This finding can be interpreted as their having a tendency to use origami in mathematics lessons in their in-service years (Nespor, 1987). Still, in-service training programs could be arranged by Ministry of National Education in order to maintain their high level of belief in the use of origami in education.

In the current study, it was revealed that prospective teachers had a slightly higher than moderate level of self-efficacy beliefs in using origami in mathematics education. According to this finding, it can be concluded that prospective teachers do not feel confident enough in using origami effectively in their teaching years (Bandura, 1997). Hence, improving prospective teachers' perceived self-efficacy level should be one of the major aims of elective origami courses. From this aspect, teacher educators should enable prospective elementary mathematics teachers to use origami in other courses, such as methodology courses and teaching practice courses; moreover, in elementary schools in order to increase their level of self -efficacy.

5.5. Recommendations for Further Research Studies

In the current study, data were obtained via two newly developed scales named OMEBS and OMESS. These scales were developed with the aim of filling the gap in the accessible literature on measuring affective factors in education based on the use of origami. Although some validity and reliability evidences for these scales were presented in this study, more evidences are recommended with further research.

Cross sectional survey was used as the research method in the current study in order to determine prospective elementary mathematics teachers' beliefs and perceived self-efficacy beliefs towards using origami in mathematics education. As further research, longitudinal research methods may be conducted to determine the changes in origami related beliefs and perceived self-efficacy beliefs throughout the teacher education programs. Furthermore, pre-test post-test experimental designs may be used in order to see the impact of elective origami courses on beliefs and perceived self-efficacy beliefs of prospective teachers.

Prospective elementary mathematics teachers who had taken a course on origami constituted the sample group of the current study. Determining their beliefs and perceived self-efficacy beliefs is essential in order to predict their future decisions regarding the use of origami in mathematics education (Pajares, 1992). In addition to studies on prospective teachers, determining in-service teachers' beliefs and perceived self-efficacy beliefs towards using origami in mathematics education would be beneficial to see their possible decisions regarding the use of origami in mathematics lessons. Furthermore, investigating in-service teachers' level of knowledge on origami based mathematics instruction is important since most probably they had not taken any origami lesson during their undergraduate years.

In the national context the number of research studies that investigate the effect of origami based mathematics instruction is limited (e.g., Akan-Sağsöz, 2008; Çakmak, 2009). Therefore, more research on various effects of origami would be beneficial to understand the impacts of origami when used in mathematics lessons. Furthermore, research studies that observe origami based mathematics lessons in schools would be beneficial to interpret the efficacy of origami based mathematics learning environments.

According to the inferential statistics results, it was found that female participants have significantly higher beliefs and perceived self-efficacy beliefs in using origami in mathematics education when compared with male participants. Further quantitative and qualitative research studies on this issue are recommended in order to gain deeper insight into gender differences in using origami in mathematics education and determine the possible reasons underlying this difference.

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APPENDICES

APPENDIX A

Factor Matrix of OMEBS in the Pilot Study

Item	Factor Loading		Communality
	Factor 1	Factor 2	
19	**0.87**	0.01	0.75
12	**0.82**	0.12	0.63
20	**0.75**	-0.02	0.61
24	**0.71**	-0.04	0.67
2	**0.68**	0.13	0.61
8	**0.68**	-0.06	0.60
25	**0.68**	-0.18	0.67
16	**0.67**	-0.13	0.63
26	**0.63**	-0.15	0.66
21	**0.63**	-0.02	0.58
13	**0.57**	-0.05	0.47
1	**0.57**	0.01	0.45
10	**0.57**	-0.02	0.46
22	**0.56**	-0.09	0.46
7	**0.55**	0.02	0.43
6	**0.52**	-0.23	0.56
23	-0.04	**0.65**	0.57
15	-0.15	**0.63**	0.63
18	-0.12	**0.61**	0.55
9	-0.11	**0.59**	0.55
3	-0.18	**0.58**	0.51
14	-0.02	**0.56**	0.50
27	-0.02	**0.54**	0.60
5	-0.18	**0.49**	0.57
11	0.16	**0.45**	0.38
4	0.01	**0.38**	0.37
17	-0.10	**0.35**	0.39

Note. Factor loadings are values which get from Pattern Matrix. Maximum Likelihood extraction method and Oblimin with Kaiser Normalization rotation method was applied for the exploratory factor analysis. Factor loadings which are greater than 0.4 are signed with bold.

APPENDIX B

Factor Matrix of OMESS in the Pilot Study

Item number	Factor 1	Communality
4	**.91**	0.81
7	**.86**	0.71
6	**.85**	0.71
3	**.84**	0.71
5	**.84**	0.67
2	**.81**	0.66
1	**.81**	0.67
8	**.71**	0.57

Note. Factor loadings are values which get from Factor Matrix. Maximum Likelihood extraction method was applied for the exploratory factor analysis. Factor loadings which are greater than 0.4 are signed with bold.

APPENDIX C

Latest Version of OMEBS and OMESS

Sevgili öğretmen adayları,

Bu ölçek Origami'nin matematik eğitiminde kullanılmasına yönelik düşüncelerinizi belirlemek amacıyla geliştirilmiştir. Lütfen aşağıda ifade edilen her maddeyi okuyup, sizin düşüncenizi en iyi yansıtan sadece bir seçeneği işaretleyiniz. Bu çalışmadan toplanacak olan veriler sadece çeşitli bilimsel çalışmalarda ve bu çalışmaların yayımlanmasında kullanılacaktır. Yardımlarınız için teşekkür ederiz.

	kesinlikle katılmıyorum	katılmıyorum	biraz katılmıyorum	biraz katılıyorum	katılıyorum	kesinlikle katılıyorum
1. Origami matematikteki bazı soyut kavramları somutlaştırdığı için yararlıdır.	1	2	3	4	5	6
2. Origami etkinlikleri, matematik korkusu olan öğrencilerin korkularının azalmasına yardımcı olur.	1	2	3	4	5	6
3. Matematik derslerinde Origami etkinliklerini kullanmak uzun vakit alır.	1	2	3	4	5	6
4. Origami, matematikte geometri konuları haricinde <u>kullanılamaz.</u>	1	2	3	4	5	6
5. Origami etkinlikleri öğrencilerin matematiksel problem çözme becerilerini geliştirmeye	1	2	3	4	5	6
6. Matematik derslerinde Origami etkinliklerini kullanmak dersi daha eğlenceli hale getirir.	1	2	3	4	5	6
7. Origami, ilköğretim öğrencilerinin matematik ve sanat arasındaki ilişkiyi görmelerini sağlar.	1	2	3	4	5	6
8. Origami geometri kavramlarının öğretilmesini kolaylaştırır.	1	2	3	4	5	6
9. Origami etkinliklerinin yapıldığı bir matematik dersi öğrencilerin ilgisini çeker.	1	2	3	4	5	6
10. Origami öğrencilerin ispat becerilerini geliştirmelerine yardımcı olur.	1	2	3	4	5	6
11. Origami etkinliklerinin yer alacağı bir matematik dersi planlamak zordur.	1	2	3	4	5	6
12. Origami, öğrencilerin uzamsal zekâsının gelişimine yardımcı olur.	1	2	3	4	5	6

	kesinlikle katılmıyorum	katılmıyorum	biraz katılmıyorum	biraz katılıyorum	katılıyorum	kesinlikle katılıyorum
13. Okul öncesi dönemde Origami yapan çocuklar ileriki yıllarda geometri konularını daha kolay öğrenirler.	1	2	3	4	5	6
14. Origami etkinliklerinin kullanıldığı bir matematik dersi, öğrenciler için sadece bir oyundur.	1	2	3	4	5	6
15. Origami, matematik derslerinde kullanılabilecek bir öğretim aracıdır.	1	2	3	4	5	6
16. Origami aktivite temelli bir etkinlik olduğu için matematikte çağdaş öğrenme yöntemlerine uygundur.	1	2	3	4	5	6
17. Kalabalık sınıflar için matematik derslerinde Origami etkinlikleri kullanılamaz.	1	2	3	4	5	6
18. Origami'yi matematik eğitimine entegre etmek zordur.	1	2	3	4	5	6
19. Origami görsel, işitsel ve bedensel bir aktivite olduğu için matematikte etkili öğrenme sağlar.	1	2	3	4	5	6
20. Origami etkinliklerini matematik eğitiminde kullanmak öğrencilerin derse aktif olarak katılmasını sağlar.	1	2	3	4	5	6
21. Origami etkinlikleri esnasında matematik terimlerinin kullanılması, öğrencilerde matematiksel dilin gelişimine katkı sağlar.	1	2	3	4	5	6
22. Parçalı Origami* matematik eğitiminde grup çalışmasını destekleyen bir aktivitedir.	1	2	3	4	5	6
23. Origami öğrencilerin matematiksel kavramları öğrenmelerini kolaylaştırır.	1	2	3	4	5	6
24. Origami etkinliklerinin kullanıldığı bir matematik dersine karşı öğrencilerin motivasyonu (istekleri) artar.	1	2	3	4	5	6
25. Origami öğrencilerin geometrik şekiller arasındaki ilişkileri kavramalarına yardımcı olur.	1	2	3	4	5	6
26. Origami etkinliklerinin kullanıldığı bir matematik dersinde öğrenilenler çabuk unutulur.	1	2	3	4	5	6

***** Birden fazla kâğıdın eklenmesi yardımıyla yapılan Origami çeşidi, Modüler Origami.

Lütfen, her soru için kendinizi ne kadar yeterli gördüğünüzü en iyi yansıtan sadece bir seçeneği işaretleyiniz.

Kendinizi ne kadar yeterli görüyorsunuz?	**yetersiz**		**çok az yeterli**		**biraz yeterli**		**oldukça yeterli**		**çok yeterli**
1. Öğretmenlik hayatınızda Origami'yi matematik derslerinde etkin olarak kullanmada	1	2	3	4	5	6	7	8	9
2. Origami'nin ilköğretim matematik programında nasıl yer aldığını açıklamada	1	2	3	4	5	6	7	8	9
3. Origami etkinliklerinin kullanılacağı bir matematik dersini planlamada	1	2	3	4	5	6	7	8	9
4. Origami'nin matematik eğitiminde nasıl kullanılabileceğine yönelik örnekler vermede	1	2	3	4	5	6	7	8	9
5. Origami etkinlikleri esnasında matematiksel dili kullanmada	1	2	3	4	5	6	7	8	9
6. İlköğretim matematik programındaki ilgili kazanımları gerçekleştirmeye yönelik uygun bir Origami modelini* seçmede	1	2	3	4	5	6	7	8	9
7. Matematik dersindeki soyut kavramları Origami'den faydalanarak daha somut hale getirmede	1	2	3	4	5	6	7	8	9
8. Öğrencilerin Origami'yi matematikle ilişkilendirirken yaşayabilecekleri problemlere çözüm bulmada	1	2	3	4	5	6	7	8	9

***** örn. dönme hareketinin Origami ile yapılan rüzgârgülü yardımıyla anlatılması

Lütfen kişisel bilgileriniz için diğer sayfaya geçiniz ⇨

KİŞİSEL BİLGİLER

1. Cinsiyetiniz: o Erkek o Kız

2. Doğum Tarihiniz (Yıl) : ______________

3. Sınıfınız: o 1 o 2 o 3 o 4

4. Üniversiteniz: ____

5. Mezun olduğunuz lise türü:

o Düz Lise o Süper Lise o Anadolu Lisesi o Anadolu Öğretmen Lisesi o Fen Lisesi

o Diğer (Lütfen belirtiniz): _________________________________

6. Origami ile ilgili deneyimleriniz nelerdir? (*birden fazla işaretleyebilirsiniz*)

o Origami ile ilgili bir ders almak

o Özel öğretim yöntemleri dersi sırasında etkinlik yapmak/gözlemek

o Okul deneyimi dersi sırasında etkinlik yapmak/gözlemek

o Kişisel ilgi

o Yayınları (dergi, kitap, web sitesi vb.) takip etmek

o Diğer (Lütfen belirtiniz): ____

7. Origami ile ilgili yayınları (dergi, kitap, web sitesi vb.) hangi sıklıkla takip edersiniz?

o Hiçbir zaman o Bazen o Çoğunlukla o Daima

8. Origami'nin matematik eğitiminde kullanılabilecek bir öğretim aracı olduğunu düşünüyor musunuz? Neden?

____

____

____

____

____

____

Anketimiz bitmiştir. Katılımınız için teşekkür ederiz.

Çalışma hakkında detaylı bilgi almak istediğiniz takdirde;

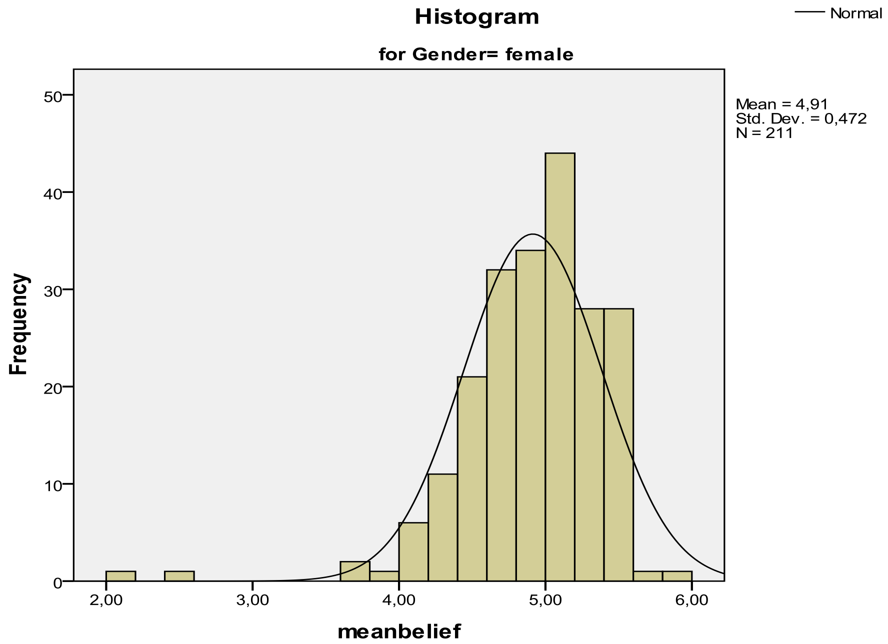
Arş. Gör. Okan ARSLAN ODTÜ - Eğitim Fakültesi EFA-37 Numaralı oda

E-mail: arokan@metu.edu.tr Tel: 0312 210 75 08

APPENDIX D

Histograms of Male and Female Participants for OMEBS and OMESS

Figure D1: Histograms of male and female participants for OMEBS



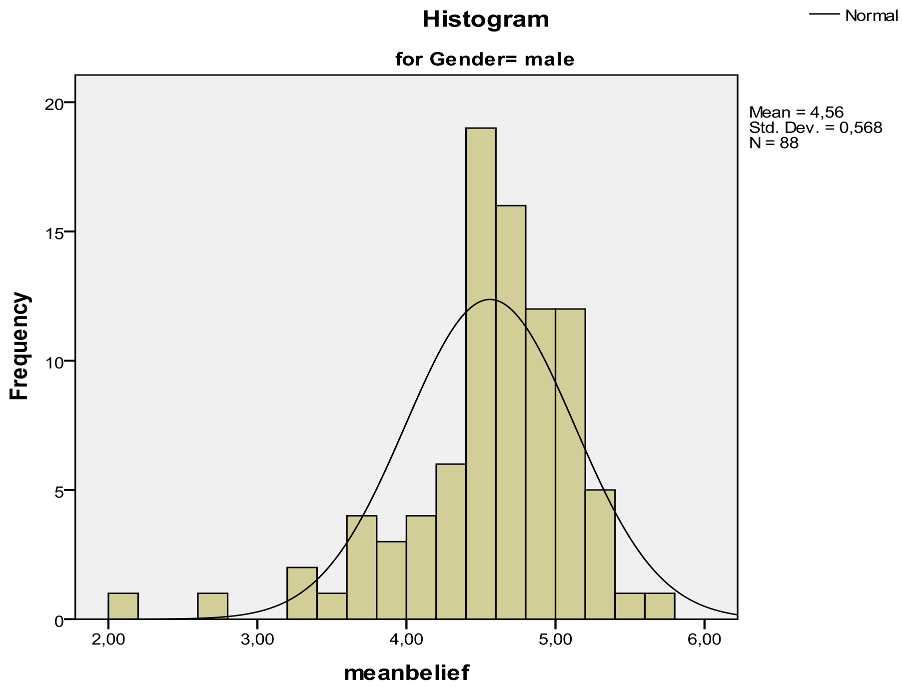
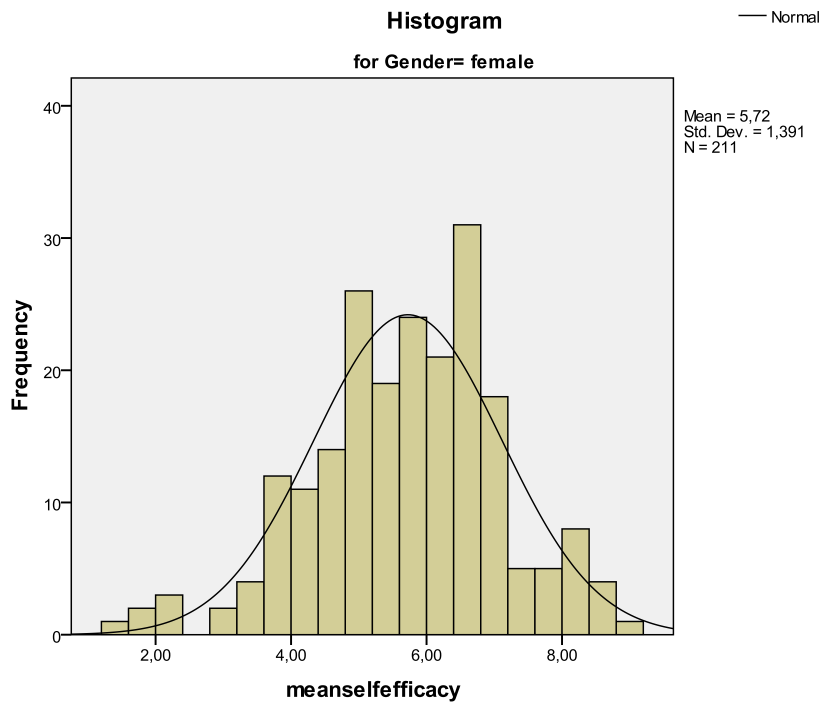
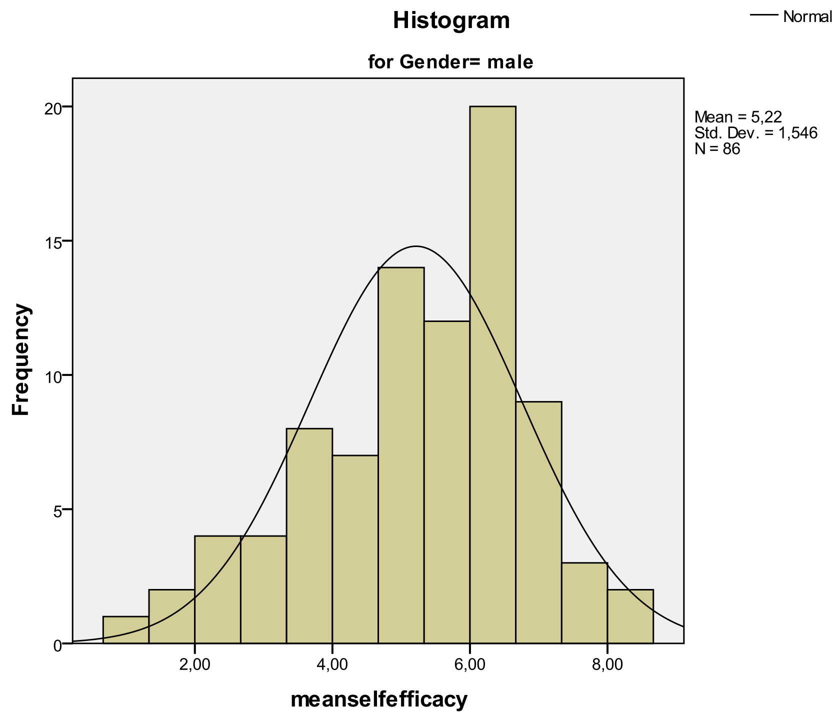


Figure D2: Histograms of male and female participants for OMESS





APPENDIX E

TEZ FOTOKOPİ İZİN FORMU

ENSTİTÜ

Fen Bilimleri Enstitüsü ☐

Sosyal Bilimler Enstitüsü ☒

Uygulamalı Matematik Enstitüsü ☐

Enformatik Enstitüsü ☐

Deniz Bilimleri Enstitüsü ☐

YAZARIN

Soyadı : ARSLAN

Adı : OKAN

Bölümü : İLKÖĞRETİM FEN VE MATEMATİK EĞİTİMİ

TEZİN ADI (İngilizce) :INVESTIGATING BELIEFS AND PERCEIVED SELF-EFFICACY BELIEFS OF PROSPECTIVE ELEMENTARY MATHEMATICS TEACHERS TOWARDS USING ORIGAMI IN MATHEMATICS EDUCATION

TEZİN TÜRÜ : Yüksek Lisans ☒ Doktora ☐

1. Tezimin tamamı dünya çapında erişime açılsın ve kaynak gösterilmek şartıyla tezimin bir kısmı veya tamamının fotokopisi alınsın. ☐
2. Tezimin tamamı yalnızca Orta Doğu Teknik Üniversitesi kullancılarının erişimine açılsın. (Bu seçenekle tezinizin fotokopisi ya da elektronik kopyası Kütüphane aracılığı ile ODTÜ dışına dağıtılmayacaktır.) ☐
3. Tezim bir (1) yıl süreyle erişime kapalı olsun. (Bu seçenekle tezinizin fotokopisi ya da elektronik kopyası Kütüphane aracılığı ile ODTÜ dışına dağıtılmayacaktır.) ☒

Yazarın imzası .... Tarih ....