THE EFFECT OF THE ORIGAMI COURSE ON PRESERVICE TEACHERS' BELIEFS AND PERCEIVED SELF-EFFICACY BELIEFS TOWARDS USING ORIGAMI IN MATHEMATICS EDUCATION

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Origami began to capture more attention in mathematics education literature because of its mathematically beneficial uses. This characteristic of origami affected the teacher education programs and some universities began to offer elective origami courses for preservice elementary mathematics teachers. In the current study, the effects of the elective origami course on preservice teachers' beliefs and perceived self-efficacy beliefs in using origami in mathematics education are investigated. Paired sample t-test results revealed that, there is not a significant change in the beliefs of preservice teachers but there is a statistically significant increase in preservice teachers' perceived self-efficacy beliefs with large effect size.

Origami, which enables to fold various models from paper, is known as the Japanese art of paper folding (Franco, 1999). Although origami originated as a hobby more than 1200 years ago (Tuğrul & Kavici, 2002), in recent years, it has become a commonly used instruction tool for mathematics lessons (Boakes, 2009).

Origami could be used to promote the geometry knowledge of students since in the folding process, geometric principles are used and moreover, it is possible to fold two and three dimensional geometric models from paper (Cipoletti & Wilson, 2004; Georgeson, 2011). Although the most known application of origami in mathematics education is geometry teaching, origami could be used for the fields of algebra (Georgeson, 2011; Higginson & Colgan, 2001); calculus (Wares, 2011) and the list could be extended. In addition to the possible usage fields of origami in mathematics education, origami also helps to gain some skills for mathematics education. For instance, paper folding exercises would lead to an improvement on students' spatial visualization skills which are accepted as an important skill in mathematics education (Boakes, 2009). Furthermore, it helps to gain mathematical problem solving ability and using mathematical terms in the folding process would improve the mathematical language of students (Cipoletti & Wilson, 2004; Robichaux & Rodrigue, 2003).

Possible benefits of origami for mathematics education have affected some countries' mathematics education programs and Turkey is one of these countries.

The Ministry of National Education (MoNE, 2009) defines origami as an instruction method which has various mathematical benefits such as improving mathematical problem solving skills, geometry knowledge and spatial visualization skills. In accordance with this view, origami activities to be used in mathematics education are given a place in the national mathematics education programs. However, treatment effects of origami were investigated in the national context with little research. In one of these studies, Kavici (2005) investigated the effect of origami exercises on preschool children's mathematical abilities and visual perception and it was found that children who had origami exercises for 11 weeks had significantly higher scores on mathematical ability and visual perception tests when compared with the children in the control group. In another study, Çakmak (2009) investigated the effect of origami on 4^{th}, 5^{th} and 6^{th} grade students' spatial ability. According to the results, she concluded that origami exercises significantly improved students' spatial visualization skills. Similar to the findings of Kavici (2005) and Çakmak (2009), in the study of Akan-Sağsöz (2008) it was found that 6^{th} grade students who had origami based mathematics instruction performed significantly higher on the test about fractions than the control group students who had not such instruction. Although research studies related with origami are limited in number, these studies found results in favor of using origami in mathematics education.

Consistent with the place of origami in the national curriculum of Turkey and the results obtained in the origami related research, some universities began to offer elective origami courses for preservice elementary mathematics teachers. In these courses, preservice teachers learn how to use origami effectively in mathematics lessons and experience how to overcome difficulties which may occur during paper folding activity. Although origami takes part in mathematics education programs and teacher education programs, it has not been studied much in terms of affective issues in the accessible literature. However, studies regarding the affective issues have an important place in mathematics education (Hannula, 2011). Among a wide range of affective issues, beliefs are attributed as an important component of mathematics education (Philipp, 2007). In spite of the consensus on the importance of studying beliefs, there is not a single belief definition in the literature (Pajares, 1992; Philipp, 2007). In the current study, the belief definition of Richardson (1996) was used as basis: "Psychologically held understandings, premises, or propositions about the world that are thought to be true" (p.103). Therefore, in its simple definition, beliefs towards using origami in mathematics education refer to individual considerations regarding the use of origami in mathematics education that are thought to be true. Although it is difficult to claim that there is a linear, unidirectional relationship between beliefs and behavior, it is generally accepted that beliefs shape predispositions towards behavior (Philipp, 2007). Therefore, investigating preservice teachers' beliefs could give a valuable view on their teaching

decisions and thus, have a great importance (Pajares, 1992; Timmerman, 2004). In accordance with these views, it is believed that investigating beliefs of preservice teachers towards using origami in mathematics education and the effect of elective origami courses on their beliefs would lead to gain some insights regarding their future origami related teaching decisions.

In addition to beliefs, research on specific types of beliefs such as self-efficacy beliefs, provides important educational benefits (Pajares, 1992). Perceived self-efficacy beliefs refer to individual judgments regarding the capability of a specific behavior (Bandura, 1997). According to Bandura (1997), there are four basic sources of perceived self-efficacy beliefs: mastery experiences, vicarious experiences, verbal persuasion, physiological and affective states. Mastery experiences are personal interpretations on one's own experiences whereas vicarious experiences are interpretations on others' observed behaviors (Joet, Usher & Bressoux, 2011). Furthermore, perceived self-efficacy beliefs are affected from verbal persuasion which refers to verbal feedbacks that one gets from the people in their close environment and also affected from physiological and affective states which refer to one's physical and emotional situation at that moment (Bandura, 1997). In these four sources, mastery experiences are interpreted as the most influential source. In the literature, perceived self-efficacy beliefs' influence on future behavior and perseverance on doing that behavior are widely mentioned (e.g., Bandura, 1997; Brand & Wilkins, 2007; Joet et al.,2011). Therefore, investigating preservice teachers' perceived self-efficacy beliefs towards using origami in mathematics education could give some clues on their origami related possible teaching decisions. Furthermore, examining the change on perceived self-efficacy beliefs after participating in an origami course would enable the interpretation of the effect of these courses.

In brief, origami is seen as an effective way of teaching mathematics and when the issue is mathematics education, affective factors are interpreted as important components of mathematics education. Therefore, the current study aims to investigate the effect of the elective origami course on preservice teachers' beliefs and perceived self-efficacy beliefs towards using origami in mathematics education. For that purpose, the following research questions are investigated with the current study:

- Is there a statistically significant effect of the elective origami course on preservice teachers' beliefs in terms of the benefits and limitations of using origami in mathematics education?
- Is there a statistically significant effect of the elective origami course on preservice teachers' perceived self-efficacy beliefs regarding the use of origami in mathematics education?

METHOD

Research Design and Sample of the Study

The current study aims to examine the effect of elective origami course on preservice elementary mathematics teachers' beliefs and perceived self-efficacy beliefs towards using origami in mathematics education. In accordance with this purpose, one group pre-posttest experimental research was selected as the research design for this study.

In Turkey, there are five universities which offer elective origami courses for preservice elementary mathematics teachers and participants of this study were selected from one of these universities. In that course, preservice teachers are firstly trained to fold origami models and learn origami diagrams. Subsequently, they learn how to choose appropriate origami model and relate folding steps to mathematical concepts. Furthermore, they learn how to change the language of origami into the language of mathematics. Subsequently, teacher candidates prepare origami activities to teach different mathematical concepts and carry out these activities in that course in order to gain experience in origami based mathematics activities. There were 36 possible teacher candidates who participated in that origami course but data for the current study was collected from 33 preservice teachers since some were absent during the data collection process. Most of the participants were in the third grade of their university education and there were just three participants from 1^{st}, 2^{nd} and 4^{th} grades. Furthermore, in accordance with the general profile of education faculties in Turkey, most of the participants were female and there were just 5 male preservice teachers in that course.

Data Collection Instruments and Process

In the data collection process, Origami in Mathematics Education Belief Scale (OMEBS) and Origami in Mathematics Education Self Efficacy Scale (OMESS) which were developed by Arslan (2012) were used as the data collection instruments. OMEBS is composed of two dimensions called benefits of origami in mathematics education with 19 items and limitations of using origami in mathematics education with 7 items. All the items in OMEBS are in 6 point Likert format ranging from strongly disagree to strongly agree. Sample items from OMEBS are given in Table 1.

Table 1: Sample Items from OMEBS

Item	Dimension
Origami is beneficial to make some abstract mathematical concepts more concrete	Benefits of origami in mathematics education
Origami makes easy to teach geometrical concepts	Benefits of origami in mathematics education

Table 1: Sample Items from OMEBS (continued)

Origami cannot be used for mathematics lessons in crowded classes	Limitations of using origami in mathematics education
Using mathematical terms during origami activity helps to improve mathematical language of students	Benefits of origami in mathematics education
It takes long time to use origami activities in mathematics lessons	Limitations of using origami in mathematics education

OMESS is composed of one dimension named as perceived self-efficacy in using origami in mathematics education. There are eight items in 9 point Likert format ranging from insufficient to very sufficient and sample items from OMESS are given in Table 2.

Table 2: Sample Items from OMESS

How well do you feel…
to plan a mathematics lesson in which origami activities will be used?
to use mathematical language during origami activities?
to find solutions to the problems of students while relating origami activity to mathematics topics?

For both of the scales, detailed literature review and expert opinions during the item development process; moreover, high factor loadings in the exploratory factor analysis and good fit indices such as RMSEA, GFI, CFI in the confirmatory factor analysis were presented as the evidences for the validity of the scales (Arslan, 2012). In addition to the validity evidences, Cronbach alpha values were investigated in order to check the internal consistency of the data obtained in pretest and posttest. As can be seen in Table 3, for both of the scales, Cronbach alpha values were calculated above .80 in pretest and posttest. These values could be interpreted as good internal consistency reliability for the data collection instruments with this sample (Pallant, 2007).

Table 3: Reliability Analysis for Data Collection Instruments

	OMEBS		OMESS	
	Pretest	Posttest	Pretest	Posttest
Cronbach Alpha	0.862	0.945	0.958	0.937

OMEBS and OMESS were administered simultaneously to 33 preservice teachers as a pretest before the beginning of the elective origami course in the spring term of 2011-2012 academic year. After 14 weeks, scales were administered again as a posttest. Data obtained from these scales were analyzed

with paired sample t-test in order to investigate whether there is a significant change in beliefs and perceived self-efficacy beliefs of teacher candidates.

RESULTS

Before conducting paired sample t-test, preliminary analyses were performed and one extreme point was removed from the data file. Furthermore, these analyses indicated that, there is no violation of the assumptions of paired sample t-test for the current data set. Therefore, it was decided that, the data file for the current study is appropriate to perform paired sample t-test.

Beliefs of Preservice Teachers in Using Origami in Mathematics Education

Preservice teachers' beliefs regarding the use of origami in mathematics education were investigated with the administration of OMEBS. As indicated in the methodology part, OMEBS has two dimensions which are benefits of origami in mathematics education and limitations of using origami in mathematics education. Paired sample t-test was performed for both dimensions of OMEBS. According to the results given in Table 4, there was an increase in teacher candidates' beliefs regarding the benefits of using origami in mathematics education from pretest (M=4.80, SD=0.50) to posttest (M=5.02, SD=0.81). However, this difference was not statistically significant, $t(31)=1.601$, $p=0.119$.

Table 4: Paired Sample T-test Results for the First Dimension of OMEBS

	Paired Differences			t	df	Sig. (2 tailed)
	Mean	Std. Deviation	Std. Error Mean			
postbenefit-prebenefit	,221	,780	,138	1,601	31	,119

Contradictory to the beliefs regarding the benefits of origami, preservice teachers beliefs' regarding the limitations of using origami in mathematics education decreased from pretest (M=3.48, SD=0.85) to posttest (M=3.34, SD=0.81). However, paired sample t-test results, which are given in Table 5, indicated that this difference was not statistically significant, $t(31)=-0.727$, $p=0.473$.

Table 5: Paired Sample T-test Results for the Second Dimension of OMEBS

	Paired Differences			t	df	Sig. (2 tailed)
	Mean	Std. Deviation	Std. Error Mean			
postlimitation-prelimitation	-,138	1,076	,190	-,727	31	,473

To sum up, according to the paired sample t-test results, it is possible to conclude that there is not a statistically significant effect of the elective origami course on preservice teachers' beliefs regarding the benefits and limitations of using origami in mathematics education.

The Impact of the Elective Origami Course on Perceived Self-Efficacy Beliefs towards Using Origami in Mathematics Education

Data obtained from the administration of OMESS in pretest and posttest was analyzed with paired sample t-test. Analysis results, which are given in Table 6, revealed that, there is a statistically significant increase in preservice teachers' perceived self-efficacy beliefs in using origami in mathematics education from pretest (M=3.02, SD=1.76) to posttest (M=6.59, SD=1.56), $t(31)=8.682$, p=0.000. Therefore, it is possible to conclude that preservice teachers' perceived self-efficacy beliefs regarding the use of origami in mathematics education significantly increased after participating in the elective origami course. Furthermore, the eta squared statistic was calculated as 0.71 and it could be interpreted as a large effect size (Green & Salkind, 1997).

Table 6: Paired Sample T-test Results for the Data Obtained from OMESS

	Paired Differences			t	df	Sig. (2 tailed)
	Mean	Std. Deviation	Std. Error Mean			
postefficacy-preefficacy	3,572	2,327	,411	8,682	31	,000

DISCUSSION AND CONCLUSION

In the current study, it was seen that, preservice teachers held similar beliefs towards using origami in mathematics education before and after the course. They strongly believe that origami has various mathematical benefits such as making abstract mathematical concepts more concrete, improving mathematical language, spatial ability and proof ability. In addition to the mathematical benefits, they strongly believe that origami has instructional benefits to make mathematics lessons more effective. Preservice teachers' beliefs of this kind are also consistent with the studies in the literature (e.g., Boakes, 2009; Cipoletti & Wilson, 2004; Higginson & Colgan, 2001). Apart from the mathematical and instructional benefits of origami, preservice teachers do not believe that origami has various limitations to be used in mathematics lessons. They do not believe that, it is difficult to use origami activities in crowded classes and to plan origami based mathematics lessons.

Preservice teachers' beliefs regarding the benefits and limitations of using origami in mathematics education remained relatively stable after the elective

origami course and no statistically significant effect of the course on participants' origami related beliefs was found. The reason might derive from the fact that, preservice teachers held already positive beliefs towards using origami in mathematics education before the course and kept their beliefs after the course. Another reason for this result might be derived from the nature of 'belief' since beliefs are generally resistant to change (Philipp, 2007). Therefore, one term course might not have a significant effect on their origami related beliefs.

When the issue is the effect of the origami course on preservice teachers' origami related beliefs, it should be noted that they did not have a chance to use origami in real teaching environments during the course. In the literature, it is generally accepted that beliefs are influenced from past experiences (Kagan, 1992), but at the same time, beliefs are also shaped by current experiences (Philipp, 2007). Therefore, apart from elective origami course, if teacher candidates had a chance to use origami activities for mathematics lessons in elementary schools, their beliefs regarding the use of origami in mathematics education might be changed. Based on origami related teaching experience, they might have different beliefs regarding the benefits or limitations of using origami in mathematics lessons. Therefore, in addition to the elective course, enabling preservice teachers to use origami in real teaching environments might be beneficial to interpret their beliefs regarding using origami in mathematics education.

Contradictory to the beliefs of preservice teachers, there was a statistically significant increase in their perceived self-efficacy belief levels in using origami in mathematics education. Furthermore, eta squared indicated that there was a large effect size which is interpreted as so important in social sciences (Pallant, 2007).

In the literature it is mentioned that origami based mathematics lessons would be very beneficial if teacher relates origami folding steps to mathematical concepts effectively (Georgeson, 2011). Therefore, teachers should be knowledgeable on how to plan and organize origami activities for mathematics lessons (Cipoletti & Wilson, 2004). Before participating in the origami course, preservice teachers felt slightly efficient to use origami in mathematics education. However, after the course, they saw themselves quite efficient to plan and carry out origami activities for mathematics lessons. Therefore, it is possible to conclude that preservice teachers were not familiar with the own nature of origami based lessons before the course and felt slightly competent to use origami in mathematics education. However, posttest results revealed that origami course was rich enough to enhance preservice teachers' knowledge and efficacy regarding the use of origami in mathematics education. Although elective course improved their efficacy level, more mastery experiences are suggested by

Bandura (1997) in order to improve perceived self-efficacy belief levels. Therefore, as stated above, enabling preservice teacher to use origami activities for mathematics lessons in elementary schools during the elective origami course might improve their efficacy level and similarly, using origami in other courses such as teaching practice, method courses might lead to an improvement on efficacy beliefs.

To sum up, current study aimed to contribute to the literature by examining the effects of elective origami course on preservice teachers' beliefs and perceived self-efficacy beliefs towards using origami in mathematics education. However, when the issue is affective factors, longitudinal studies might be beneficial to gain further insight (Hannula, 2011). Furthermore, studies with more participants and research studies comparing different countries would be beneficial to fill the gap in the related literature.

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