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Turkish Prospective Middle School Mathematics Teachers' Beliefs and Perceived Self-Efficacy Beliefs Regarding the Use of Origami in Mathematics Education

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The purpose of this study was to investigate beliefs and perceived self-efficacy beliefs of Turkish prospective elementary mathematics teachers in using origami in mathematics education. Furthermore, gender differences in their beliefs and perceived self-efficacy beliefs were investigated. Data for the current study was collected via Origami in Mathematics Education Belief Scale (OMEBS) and Origami in Mathematics Education Self-Efficacy Scale (OMESS). Descriptive analysis results indicated that prospective mathematics teachers strongly believe that origami is beneficial and effective to be used in mathematics education. However, their perceived self-efficacy beliefs were at little higher than moderate level. Lastly, independent sample t-test results revealed that female teacher candidates have significantly higher beliefs and perceived self-efficacy beliefs in using origami in mathematics education when compared with male teacher candidates.

Keywords: beliefs, origami, prospective mathematics teachers, self-efficacy beliefs

INTRODUCTION

Origami, the Japanese art of paper folding, has become an important research topic in mathematics education since origami possesses great mathematical potential when used in education (Boakes, 2009; Higginson & Colgan 2001; Robichaux & Rodrigue, 2003). In mathematics education, origami is most frequently

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used in the teaching of geometry since origami entails natural geometric principles in the folding process (Cagle, 2009; Cornelius & Tubis, 2009; Demaine & O'Rourke, 2007). Therefore, origami can be used to promote the geometry knowledge of students (Arıcı & Aslan-Tutak, 2015; Canadas et al., 2010; DeYoung, 2009; Johnson, 1999). In addition to geometry, origami can also be used in teaching topics related to algebra (Cornelius & Tubis, 2009; DeYoung, 2009; Franco, 1999; Georgeson, 2011; Higginson & Colgan, 2001); fractions (Canadas et al., 2010; Coad, 2006; DeYoung, 2009; Pagni, 2007); spatial visualization (Arıcı & Aslan-Tutak, 2015; Boakes, 2008, 2009; Çakmak, Işıksal, & Koç, 2014); and linear measurement (DeYoung, 2009; Tuğrul & Kavici, 2002). In other words, although the use of origami in mathematics education is common in topics related to geometry, it is popular in other domains of mathematics. 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 usage of mathematical language (Cagle, 2009; Cipoletti & Wilson, 2004; Hartzler, 2003; Mastin, 2007; Robichaux & Rodrigue, 2003).

Literature review on the existing research studies mostly focus on how origami can be effectively used in mathematics lessons, and on experiences gained in origami-based mathematics lessons (e.g., Georgeson, 2011; Golan & Jackson, 2010; Higginson & Colgan, 2001; Wares, 2011). However, studies that investigate the treatment effects of origami-based mathematics lessons are limited (Arıcı & Aslan-Tutak, 2015; Boakes, 2008). These limited research studies on the treatment effects of origami-based mathematics instruction generally revealed significant results in favor of origami-based mathematics lessons (e.g., Arıcı & Aslan-Tutak, 2015; Boakes, 2009; Çakmak, Işıksal, & Koç, 2014; Yuzawa & Bart, 2002). The promising results of such studies 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' programs in Turkey. Some universities have begun to offer elective courses on origami-based mathematics lessons in order to introduce origami to prospective mathematics teachers. These courses aim to improve teaching practices of prospective teachers by helping them make use of origami-based mathematical activities, but there is a lack of research in both Turkish and international context which gives voice to prospective teachers about what they believe regarding the use of origami in mathematics lessons. However, one needs to first understand beliefs in

State of the literature

- In recent years, origami began to take increasing attention in education literature because of its beneficial uses in mathematics education.
- In line with the potential of origami in mathematics education, some teacher education programs in the national and international context began to train prospective mathematics teachers to use origami effectively in mathematics education.
- Although there are attempts to train prospective teachers to use origami in mathematics education, there is a lack of research which gives voice to these teacher candidates in order to explore their beliefs and perceived self-efficacy beliefs regarding the use of origami in mathematics education.

Contribution of this paper to the literature

- Prospective mathematics teachers in the current study strongly believe that origami is beneficial to be used in mathematics education. Furthermore, they do not believe that it has serious limitations to be used in mathematics lessons.
- Although participant prospective teachers took a course on the effective use of origami in mathematics education, they do not feel highly efficacious to implement origami-based mathematics lessons. This result indicates that prospective teachers need further support in order to improve their perceived-self efficacy level.
- Female prospective teachers' beliefs and perceived self-efficacy beliefs regarding the use of origami in mathematics education are significantly higher than male prospective teachers. The underlying reasons of this difference should be investigated in the further studies.

order to understand teaching practice (Cross, 2009). Therefore, research studies on prospective teachers and specifically on their beliefs possess great educational benefits (Pajares, 1992).

There are increasing studies on beliefs, but there is no common definition of belief in the literature (Philipp, 2007). In the current study, Richardson's definition of the term *belief* was used as basis: 'Psychologically held understandings, premises, or propositions about the world that are thought to be true' (1996, p. 103). Based on this definition, beliefs in using origami in mathematics education refer to prospective teachers' opinions which are felt to be true about origami when it is used in mathematics lessons. Beliefs are based on past experiences (Hart, 2002; Pajares, 1992) and generally stable over time (Cross, 2009; Kagan, 1992). Furthermore, beliefs develop over a long time, and it is not possible to have a consensus on specific beliefs since it depends on personal judgments (Philipp, 2007). In the belief development process, both personal and social factors play a key role (Richardson, 1996). In other words, teacher characteristics (e.g., gender, race), teachers' knowledge, and teaching-related experiences in the social contexts all have an effect on the development of beliefs (Clark et al., 2014).

When the focus is on beliefs, there is a wide range of topics in the mathematics education literature. Although the majority of focus is on the beliefs about the nature of mathematics, mathematics teaching, and mathematics learning (Beswick, 2012), there are also studies which investigate beliefs about some specific teaching methods and/or tools in mathematics teaching. For instance, Chan (2015) focused on teachers' beliefs about the use of dynamic geometry software for teaching mathematics whereas Alpaslan, Işıksal, and Haser (2014) focused on prospective teachers' beliefs towards using history in mathematics teaching. Parallel to these studies, the focus in the current study is on beliefs regarding the use of origami in mathematics teaching since there is a gap in origami-related literature on such a topic. Prospective teachers' possible decisions regarding the use of origami in their mathematics instruction might be predicted since there is a common conception in related literature that beliefs act as filters and affect predispositions towards behavior (Beswick, 2012; Cross, 2009; Philipp, 2007). Determining beliefs of prospective teachers would be beneficial not only in predicting their possible teaching behavior but also in organizing university and in-service programs for effective teaching (Clark et al., 2014; Kagan, 1992).

There is no research study exists in the literature specifically focused on beliefs regarding the use of origami in mathematics education, but studies that focus on beliefs about mathematics teaching might be beneficial to understand Turkish prospective elementary mathematics teachers' perspectives on how mathematics should be taught. However, there is no consensus in related studies. In some of the studies, it was noted that prospective elementary mathematics teachers hold traditional mathematics teaching beliefs (e.g., Dede & Karakuş, 2014; Sinan & Akyüz, 2012). On the other hand, there are studies which stressed that prospective elementary mathematics teachers' beliefs are in line with the constructivist learning theory (e.g., Doruk, 2014; Kayan, Haser, & Işıksal-Bostan, 2013). Therefore, investigating beliefs of Turkish prospective mathematics teachers' beliefs on using origami in mathematics education would contribute to these contradictive results from an alternative point of view.

In addition to beliefs, research on specific types of beliefs, particularly on perceived self-efficacy beliefs, is important in education (Pajares & Miller 1994). '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 (Bandura, 1997). Moreover, self-efficacy can be affected by others' experiences, which refers to the vicarious experience (Joet, Usher, & Bressoux, 2011). By referring to the other two sources Bandura (1997) explained that 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.

Furthermore, perceived self-efficacy beliefs affect personal choices (Pajares & Kranzler 1995), motivation towards a specific behavior (Bandura, 1977), and perseverance in given tasks (Bandura, 2006). These characteristics make perceived self-efficacy a major determinant of behavior, and thus, investigating these beliefs will help to predict possible future behaviors (Bandura, 1997). Therefore, research studies on prospective teachers' self-efficacy beliefs are expected to reveal valuable information about their future teaching behaviors, which may form current educational policies (Brand & Wilkins, 2007). In relevant studies conducted with Turkish prospective teachers, Çakıroğlu and Işıksal (2009) stated that mathematics teacher candidates had high mathematical self-efficacy beliefs, but when the focus is on teaching mathematics, the findings were inconsistent. Although Koç (2011) reported high self-efficacy belief levels of prospective teachers on teaching mathematics, Mehmetlioğlu and Haser (2013) noted that prospective teachers do not feel ready to teach mathematics.

As regards to the use of origami in mathematics education, investigating perceived self-efficacy beliefs of prospective teachers draws great attention. The reason derives from the fact that origami-based mathematics lessons have a unique lesson structure, and thus, some teaching requirements are essential for effective instruction (Golan & Jackson, 2010). To put it in different way, there are elective courses in the national context for prospective teachers in order to gain knowledge and confidence in origami-based mathematics lessons, but the extent to which teacher candidates feel confident in using origami in mathematics education has not been studied in the accessible literature.

As for the affective factors in mathematics education, early studies in the literature indicate that gender is an important factor to be studied since female and male teachers and teacher candidates might hold different beliefs about mathematics teaching (Clark et al., 2014; Yazıcı & Ertekin, 2010). However, there is no consensus on how mathematics teaching beliefs are differed by gender (Li, 1999). Some studies in the literature suggest that female teachers hold more constructivist mathematics teaching beliefs and male teachers hold more traditional mathematics teaching beliefs (Kayan, Haser, & Işıksal 2013; Li, 1999) and noted that female teacher candidates have significantly more positive beliefs towards using new orientations and tools while teaching mathematics (e.g., Alpaslan, Işıksal, & Haser, 2014). On the other hand, some studies did not find significant differences on mathematics teaching beliefs and mathematics teaching efficacy beliefs based on gender (Duatepe-Paksu, 2008; Işıksal & Çakıroğlu, 2005). Yet, the role of gender in beliefs remained uncertain in the literature, and there is a need for further research in order to determine the effects of gender in mathematics-related beliefs (Clark et al., 2014; Fennema, 2002). Therefore, the investigation of 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 these prospective teachers' perspectives in using origami in mathematics lessons. In other words, 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 of origami as a teaching tool.

To sum up, origami is regarded as an important mathematics teaching tool in the literature and growing attention is attributed to studies on this topic. However, despite the educational outcomes of studies related to prospective teachers' beliefs and efficacy beliefs, there is a lack of research in the origami-related literature which focuses on these affective factors and gives voice to prospective teachers. Therefore, the purpose of the current study is threefold: 1) to investigate prospective teachers' beliefs towards using origami in mathematics education; 2) to investigate perceived self-efficacy beliefs of prospective teachers in using origami in mathematics education; 3) to identify whether these beliefs and perceived self-efficacy beliefs differ by gender. In accordance with the purpose of the study, the following research questions were investigated in the current study:

- What are the beliefs of prospective elementary mathematics teachers regarding the benefits and limitations of using origami in mathematics education?
- What are the prospective elementary mathematics teachers' perceived self-efficacy beliefs in using origami in mathematics education?
- Is there a statistically significant mean difference between female and male prospective elementary mathematics teachers' beliefs in using origami in mathematics education?
- Is there a statistically significant mean difference between female and male prospective elementary mathematics teachers' perceived self-efficacy beliefs in using origami in mathematics education?

METHOD

Context

Turkish high school students have to pass a national exam which is administered by the Students Selection and Placement Center (ÖSYM) in order to be a university student in Turkey. Based on the scores obtained from this exam, they can choose the departments of universities in which they pursue their higher education. In Turkey, there are totally 168 universities and 61 of these universities have a department of elementary mathematics education. Students, who graduated from this department, are eligible to be a mathematics teacher in 5th, 6th, 7th, and 8th grades. All of the students in this department have to take some must courses related to mathematics and mathematics education. In addition to the courses related to mathematics, they also have to take some courses such as Physics, Turkish, English, History, Statistics, Classroom Management, and School Practice. Apart from the must courses, there are also elective courses for prospective teachers, and these courses might vary based on the university.

Participants

In the current study, purposive sampling method was used to select participants, and the main criterion was prospective teachers' lesson experience about origami-based mathematics lessons during their enrollment in undergraduate programs. In Turkey, origami-based mathematics instruction experience is offered to prospective teachers via elective origami courses in five universities. In addition to these five universities, one university trains prospective teachers on origami-based mathematics instruction through method and teaching practice courses. There were 143 prospective elementary mathematics teachers from three different universities in the pilot study, and all the participants had a lesson experience on origami-based mathematics instruction via elective origami course or method courses. In the main study, 299 prospective elementary mathematics teachers from three different universities participated in the study. Two hundred eleven of the participants in the main study were female (70.6%) and 88 of the participants were male (29.4%). All of the participants had an experience about origami through elective courses related to using origami in mathematics education. In addition to their elective origami course experience, 72 prospective teachers (24.1%) had experience in origami-based mathematics lessons through method courses, and 61 prospective teachers (20.4%) had experience through school practice course. One hundred participants (33.4%) stated that they have a personal interest to origami while 49 participants (16.4%) indicated that they follow origami related publications.

Data collection instruments

In the current study, prospective teachers' beliefs towards using origami in mathematics education were measured via Origami in Mathematics Education Belief Scale, and their perceived self-efficacy in using origami in mathematics education were measured via Origami in Mathematics Education Self-Efficacy Scale.

Origami in Mathematics Education Belief Scale (OMEBS) consists of 26 items within a 6-point Likert scale. All the items aim to establish prospective teachers' beliefs towards using origami as an instruction tool in mathematics lessons. In accordance with this aim, 1 shows 'completely disagreement' to the statement in the item while 6 indicates 'completely agreement' to the statement. 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.

In the item development process, a detailed literature review was carried out, and moreover, three experts' opinions regarding the items in the scale were taken into consideration. Then, an interview was conducted with three prospective teachers. Some slender changes were made for the better understandability according to their opinions. After the item development process, data obtained from the pilot study was analyzed with exploratory factor analysis techniques in PASW18. Results revealed that OMEBS composed of two dimensions, and these dimensions were named as *benefits of origami in mathematics education* (19 items) and *limitations of using origami in mathematics education* (7 items) respectively. The highest and the lowest item factor loadings in both dimensions of OMEBS can be seen in Table 1.

In accordance with the findings of the exploratory factor analysis, the model with two dimensions was tested with confirmatory factor analysis via LISREL. Calculated RMSEA (0.091), CFI (0.90), GFI (0.90), and Normed Chi Square (3.45) fit indices were interpreted as the hypothesized model of OMEBS fits the data well (Çokluk, Şekercioğlu, and Büyüköztürk 2010; Hu and Bentler 1999; Kelloway 1998).

In addition to the fit indices via confirmatory factor analysis, Cronbach alpha coefficients were calculated for each dimension in order to check the internal consistency of the data obtained in the main study. Cronbach alpha coefficients were calculated as 0.95 for *benefits of origami in mathematics education* dimension and

Table 1. Item factor loadings for OMEBS

Item	Factor1	Factor2	Communality
Origami enables effective learning in mathematics since it is a visual, audible and physical activity.	0.87	0.01	0.75
Using origami activities in mathematics lessons makes lessons more amusing.	0.52	- 0.23	0.56
It is difficult to plan a mathematics lesson in which origami activities will be used.	- 0.12	0.61	0.55
Origami cannot be used in mathematics topics except geometry.	0.01	0.38	0.37

Table 2. Item factor loadings for OMESS

Item	Factor1	Communality
How well do you feel to give examples about how origami can be used in mathematics education?	0.91	0.81
How well do you feel to find solutions to the problems of students while relating origami activity to mathematics topics?	0.71	0.57

0.66 for *limitations of using origami in mathematics education* dimension. Although the first dimension's Cronbach alpha coefficient value was interpreted as quite high, the value of 0.66 for the second dimension was interpreted as low (Pallant 2007). However, Pallant (2007) stated that low Cronbach alpha values are common 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).

As the other data collection instrument, Origami in Mathematics Education Self-Efficacy Scale (OMESS) consists of 8 items within a 9-point Likert 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 that means sufficient perceived self-efficacy to use origami effectively as a teaching tool. Scoring high scores in the current scale refers to feeling confident to use origami in mathematics education, and scoring low in this scale refers to feeling not confident in using origami in mathematics education.

Similar item development process of OMEBS was followed for OMESS. According to the exploratory factor analysis results, it was decided that OMESS composed of one dimension which explains 73% of the total variance. The single dimension of OMESS was named as *perceived self-efficacy in using origami in mathematics education*. The highest and the lowest item factor loadings for the single dimension of OMESS are presented in Table 2.

Data obtained through the main study was analyzed with confirmatory factor analysis techniques in order to confirm the hypothesized factor structure of OMESS. According to the confirmatory factor analysis results, calculated fit indices such as RMSEA (0.068), CFI (0.99), GFI (0.97), and Normed Chi-Square (2.37) were interpreted as satisfactory to confirm the factor structure of the scale (Çokluk, Şekercioğlu, & Büyüköztürk, 2010; Hu & Bentler, 1999; Kelloway, 1998). Apart from the validity evidences, Cronbach alpha coefficient was calculated for the single dimension of the scale in order to check the internal consistency of the data obtained in the main study. It was calculated as 0.94 and interpreted as quite high (Pallant, 2007).

To sum up, establishing the factor structure of scales, and then, confirming this structure with confirmatory factor analysis can be interpreted as a strong evidence for the construct validity of the scales (Crocker & Algina, 1986; Çokluk, Şekercioğlu, & Büyüköztürk, 2010). Furthermore, calculating high Cronbach alpha values for a scale indicates that data collection instrument give reliable results for the selected sample (Pallant, 2007). Therefore, when the validity and reliability evidences for OMEBS and OMESS are taken into consideration, it is possible to conclude that these scales are valid and reliable instruments to measure beliefs and perceived self-efficacy beliefs in using origami in mathematics education. In order to have a better insight about data collection instruments, OMEBS and OMESS are given in Appendix A and B respectively.

Data analysis

In order to investigate first and second research questions of the current study, descriptive statistics was calculated respectively for the dimensions of OMEBS and OMESS. Furthermore, independent sample t-tests were conducted in order to investigate gender differences on beliefs and perceived self-efficacy beliefs regarding the use of origami in mathematics education. In t-tests, total mean scores obtained from OMEBS and OMESS were selected as dependent variable whereas gender was selected as independent variable. Since OMESS has one dimension, total mean score for this dimension was the dependent variable. However, there are two dimensions in OMEBS which requires calculating total mean score by considering meanings of items in these dimensions. Scoring high in the items of the *benefits of origami in mathematics education* dimension refers to positive beliefs regarding the use of origami in mathematics education. On the contrary, scoring high in the items of *limitations of using origami in mathematics education* dimension refers to negative beliefs regarding the use of origami in mathematics education. Therefore, prospective teachers' responses to the items in the *limitations of using origami in mathematics education* dimension were reversed, and total mean score for OMEBS was calculated. After this process, normal distribution and homogeneity of variances assumptions of independent sample t-test were assured for the data obtained through the administration of OMEBS and OMESS, and analyses were applied.

RESULTS

Beliefs of prospective teachers towards using origami 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 to the benefits of origami when used in mathematics education. The mean score of these 19 items was calculated respectively as 5.33 out of 6 for female prospective teachers, 4.94 for male prospective teachers, and 5.22 for the whole sample. Details about the calculated mean scores can be seen in Table 3.

These high mean scores obtained from both female and male teacher candidates indicated that Turkish prospective elementary mathematics teachers, who have origami-based mathematics instruction lesson experience, believe that origami is not only beneficial in topics related to geometry but also has several beneficial uses in mathematics education. Moreover, prospective teachers strongly believe that using origami activities in mathematics education has various mathematical benefits for students such as making mathematical concepts more concrete, helping to understand geometry topics and relationship between geometrical shapes, and helping to improve spatial thinking ability and mathematical language. In addition to the mathematical benefits of origami, prospective teachers also believe that origami has instructional benefits such as enabling active and effective learning while also being appropriate for contemporary learning theories.

In OMEBS, there are 7 items about the possible *limitations of using origami in mathematics education*. The mean score of these 7 items was calculated as 2.91 for

Table 3. Descriptive statistics for the first dimension of OMEBS

	Mean (M)	Standard Deviation (SD)
Female	5.33	0.58
Male	4.94	0.67
Whole Sample	5.22	0.63

Table 4. Descriptive statistics for the second dimension of OMEBS

	Mean (M)	Standard Deviation (SD)
Female	2.91	0.65
Male	3.29	0.75
Whole Sample	3.02	0.70

Table 5. Descriptive statistics for the single dimension of OMESS

	Mean (M)	Standard Deviation (SD)
Female	5.72	1.39
Male	5.22	1.55
Whole Sample	5.58	1.45

female teacher candidates and 3.29 for male teacher candidates. Furthermore, the mean score for the whole sample was calculated as 3.02 out of 6, and details can be seen in Table 4.

In the 6 point Likert type 3 corresponds to partly disagreement. Although male prospective teachers were more likely to agree with the items in this dimension when compared with female prospective teachers, it is possible to state that both female and male prospective teachers partly disagreed with the items in this dimension, and do not believe that origami has various limitations to be used in mathematics education. In other words, they do not believe that; origami is just a game, it is difficult to plan origami activities to be used in mathematics lessons, and these activities cannot be used in mathematics topics except geometry, and cannot be implemented in crowded classes.

Perceived self-efficacy beliefs of prospective teachers in using origami in mathematics education

One of the purposes of the current study is to investigate prospective teachers' perceived self-efficacy beliefs towards using origami in mathematics lessons and for this purpose, OMESS was used as data collection instrument. The mean score of total 8 items was calculated as 5.72 out of 9 for female teacher candidates, 5.22 for male teacher candidates and 5.58 for the whole sample. These mean scores could be interpreted as slightly higher than moderate level, and details are given in Table 5.

Calculated mean scores for female and male teacher candidates indicated that Turkish prospective elementary mathematics teachers see themselves moderately competent on the preparation and implementation of origami activities for mathematics lessons. In other words, they feel moderately competent to choose and plan origami activities before the lesson, and also, feel moderately competent to organize and implement these activities during the lesson in accordance with the mathematical purposes of the lesson.

Gender differences in prospective teachers' beliefs and perceived self-efficacy beliefs in using origami in mathematics education

In order to investigate gender differences in prospective teachers' beliefs and perceived self-efficacy beliefs in using origami in mathematics education, independent sample t-tests were conducted for the data obtained through OMEBS and OMESS.

According to the independent sample t-test results for OMEBS, there was a significant mean difference between female and male teacher candidates' beliefs towards using origami in mathematics education ($t(297)= 5.60$, $p < .0005$). Therefore, there is enough evidence to conclude that female teacher candidates ($M=4.99$, $SD=.51$) have significantly more positive beliefs in using origami in mathematics education than male teacher candidates (M=4.61, SD=.61). Eta squared was calculated as .10 and interpreted as the magnitude of the differences in OMEBS means is moderate (Cohen, 1988).

Similarly, independent sample t-test results for the data obtained through OMESS indicated that there is a significant mean difference between female and male teacher candidates in perceived self-efficacy beliefs in using origami in mathematics education ($t(295)=2.77$, $p < .01$). Based on the analysis, it was seen that female teacher candidates (M=5.72, SD=1.39) feel more efficacious to use origami in mathematics education when compared with male teacher candidates (M=5.22, SD=1.55). However, calculated eta squared value (.03) indicated that effect size is small in degree (Cohen, 1988).

DISCUSSION

The current study aimed to contribute to the existing literature by investigating beliefs and perceived self-efficacy beliefs of prospective elementary mathematics teachers on the use of origami in mathematics education. Furthermore, gender differences on these beliefs and perceived self-efficacy beliefs were investigated.

According to the descriptive analysis results for the benefits of origami in mathematics education dimension of OMEBS, it is possible to conclude that prospective elementary mathematics teachers believe that origami is a beneficial instructional tool to be used in mathematics lessons. Prospective teachers' beliefs regarding the benefits of origami is consistent with the studies in the origami-related literature. Possible benefits of using origami in mathematics lessons are commonly mentioned in various studies in the literature and prospective teachers in the current study are in agreement with these benefits. Some of these benefits are: making some abstract mathematical concepts more concrete (e.g., Georgeson, 2011), being a quite effective way of teaching geometry (e.g., Arıcı & Aslan-Tutak, 2015; Golan & Jackson, 2010), and helping to improve students' mathematical language (e.g., Cipoletti & Wilson, 2004; Hartzler, 2003; Robichaux & Rodrigue, 2003). The findings of the current study might also be interpreted as consistent with the ones in which prospective elementary mathematics teachers held constructivist mathematics teaching beliefs (e.g., Doruk, 2014; Kayan, Haser, & Işıksal-Bostan, 2013). In these studies, it is mentioned that prospective teachers support the idea that using activities that make mathematical concepts more concrete in mathematics lessons as in origami-based mathematics lessons. Similarly, from the viewpoint of Sze (2005), 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. In this study, prospective teachers might believe that origami is beneficial to be used in mathematics education since the teacher education programs in Turkey are based on activity-based learning, and they might consider the use of origami beneficial in constructivist learning environments as an activity-based approach.

Descriptive analysis results of the dimension entitled limitations of using origami in mathematics education of OMEBS revealed that prospective teachers do not interpret origami as an instruction tool 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 related to using origami in mathematics education, and with the effects of this experience, they know how to overcome some problems which may occur while using origami activities in mathematics lessons. These characteristics of the participants might affect their responses on the items related to possible limitations of origami when used in mathematics education and thus, they might not believe that origami has serious limitations to be used in mathematics lessons.

However, it is beneficial to bear in mind that prospective teachers' beliefs regarding the limitations of using origami in mathematics lessons were not as strong as their beliefs about the benefits of origami. Therefore, the results might be interpreted as prospective teachers believe that in some cases, the use of origami activities in mathematics lessons might be limited. However, the findings of the current study are limited at this point, and there is a need for further research in order to understand in which cases or aspects, prospective teachers believe origami-based mathematics activities might be limited.

Despite prospective teachers' positive beliefs regarding the use of origami in mathematics lessons, their perceived self-efficacy beliefs were not as high as expected. According to the descriptive analysis results for OMESS, prospective elementary mathematics teachers' perceived self-efficacy beliefs in using origami in mathematics education were slightly higher than the moderate level. These results do not support the findings of the earlier studies which reported Turkish prospective elementary mathematics teachers' high mathematics teaching efficacy levels (e.g., Çakıroğlu & Işıksal, 2009; Koç, 2011) in that prospective teachers did not feel efficacious enough to effectively use origami as a teaching tool for mathematics lessons. In other words, similar with the findings of Mehmetlioğlu and Haser (2013), prospective teachers did not feel ready enough to implement origami-based activities in mathematics education. It might be concluded that prospective teachers' positive beliefs regarding the use of origami in mathematics education were not supported by their perceived self-efficacy beliefs which might prevent them to use origami in their future mathematics teaching practices. Therefore, there is a need for further support of prospective teachers in order to improve their perceived self-efficacy on the use of origami in mathematics lessons.

Mastery experiences are described as a crucial source in perceived self-efficacy beliefs (Bandura, 1977). This view is also supported in the literature with research studies, and these studies underlined that methodology courses and teaching practices have positive impacts on prospective teachers' teaching efficacy (e.g., Brand & Wilkins, 2007; Swars et al., 2009). When the focus is on using origami activities in mathematics education, elective courses on origami can be accepted as a type of methodology course since these courses aim to teach effective ways of using origami in mathematics lessons. Participants of the current study had taken an elective origami course, but their efficacy levels in using origami as a mathematics teaching tool were not high enough as expected. Supported with the findings of research studies in the literature, teaching practices in addition to methodology courses are important in gaining efficacy. Therefore, as a future attempt, 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.

As the final purpose of the current study, gender differences in prospective teachers' beliefs and perceived self-efficacy beliefs regarding the use of origami in mathematics education were investigated. Analysis revealed that female prospective teachers have significantly higher mean scores on beliefs and perceived self-efficacy beliefs in using origami in mathematics education than those of male prospective teachers. This finding supported the view that female teacher candidates hold more constructivist mathematics teaching beliefs (e.g., Li, 1999) whereas male teacher candidates are more skeptical to use new teaching tools in mathematics education (e.g., Alpaslan, Işıksal, & Haser, 2014). 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 (Sze, 2005; Tuğrul & Kavici, 2002), might draw female prospective teachers' attention more, and as a result, they might have higher mean scores on beliefs in using origami in mathematics education.

Similar to the beliefs in using origami in mathematics education, female prospective teachers showed significantly higher efficacy beliefs than male prospective teachers in using origami in mathematics education. However, a small effect size was calculated. In relevant studies, it was seen that gender is not an influential factor on prospective teachers' beliefs about how efficacious and ready they are to teach mathematics (e.g., Işıksal & Çakıroğlu, 2009; Mehmetlioğlu & Haser, 2013). On the other hand, as a result of social environment, females are more likely to do activities which require the use of fine motor skills. This claim is also supported with the research studies in which it is found that girls' fine motor skills are significantly better than boys (e.g., Morley, Till, Ogilvie, & Turner, 2014). In other words, having more mastery experiences in the previous years on using fine motor skills might help female teacher candidates to become more competent on paper folding activities (Bandura, 1997) which in turn enhance their efficacy beliefs on using origami in mathematics education. Therefore, it could be deduced that in the early stages of education, learning environments in which fine motor skills are used should also be created for males. If males engage in paper folding activities earlier, they might have higher perceived self-efficacy towards using origami in mathematics education in later years.

To sum up, the current study aims to contribute to the literature by investigating prospective elementary mathematics teachers' beliefs and perceived self-efficacy beliefs regarding the use of origami in mathematics education. In line with this purpose, longitudinal surveys might be conducted to determine the changes in origami-related beliefs and perceived self-efficacy beliefs throughout the teacher education programs. 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. Moreover, further quantitative and qualitative research studies on gender differences in using origami in mathematics education are recommended in order to gain deeper insight on this issue and determine the possible reasons underlying this difference.

AUTHORS' NOTE

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Appendix A

Origami in Mathematics Education Belief Scale (OMEBS)

Items in the Benefits of Origami in Mathematics Education Dimension of OMEBS
Origami is beneficial to make some abstract mathematical concepts more concrete.
Origami activities help to reduce mathematics anxiety of students.
Origami activities help students to improve their mathematical problem solving ability.
Using origami activities in mathematics lessons makes lessons more amusing.
Origami enables elementary students to see the relationship between mathematics and art.
Origami makes easy to teach geometrical concepts.
Mathematics lessons in which origami activities are used, take attention by students.
Origami helps students to improve their proving ability.
Origami helps to improve spatial ability of students.
Children who made origami in preschool time learn geometry subjects easily in later years.
Origami is an instruction tool which can be used in mathematics lessons.
Origami enables effective learning in mathematics since it is a visual, audible and physical activity.
Origami is appropriate for contemporary learning theories in mathematics since it is an activity based approach.
Using origami activities in mathematics education enables students to actively attend to lesson.
Using mathematical terms during origami activity helps to improve mathematical language of students.
Modular origami is an activity which promotes group working in mathematics lessons.
Origami makes students learning of some mathematical concepts easier.
Motivation of students increases to mathematics lessons in which origami activities are used.
Origami helps students to understand the relationship between geometrical shapes.

Items in the Limitations of Using Origami in Mathematics Education Dimension of OMEBS
It takes long time to use origami activities in mathematics lessons.
Origami cannot be used in mathematics topics except geometry.
It is difficult to plan a mathematics lesson in which origami activities will be used.
A mathematics lesson, in which origami activities are used, is just a game for students.
Origami cannot be used for mathematics lessons in crowded classes.
It is difficult to integrate origami into the mathematics education.
It is easy to forget the things learned in a mathematics lesson in which origami activities are used.

Appendix B

Origami in Mathematics Education Self-Efficacy Scale (OMESS)

How well do you feel…
to use origami effectively in mathematics lessons during your teaching years?
to explain the place of origami in the national elementary mathematics curriculum?
to plan a mathematics lesson in which origami activities will be used?
to give examples about how origami can be used in mathematics education?
to use mathematical language during origami activities?
to choose appropriate origami model in order to gain objectives in the elementary mathematics curriculum?
to make abstract mathematical concepts more concrete by using origami activities?