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Origami in Mathematics Education: The Development and Validation of an Origami-Related Self-Efficacy Scale[1]

Matematik Eğitiminde Origami Kullanımına Yönelik Öz Yeterlik Ölçeği Geliştirilmesi ve Geçerlik Çalışmaları

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ABSTRACT. The current study aims to develop and validate a scale in order to measure preservice and/or in-service teachers' self-efficacy beliefs regarding the use of origami in mathematics education. In line with this purpose, Origami in Mathematics Education Self-Efficacy Scale (OMESS) is developed and administered to 143 preservice teachers in the pilot study. Exploratory factor analysis results indicate that single dimension explains 73 percent of the total variance. In the main study, OMESS is administered to 299 preservice teachers. Obtained data is analyzed with confirmatory factor analysis techniques, and RMSEA is found to be 0.068, NC is found to be 2.37, CFI and NFI are found to be 0.99. Furthermore, Cronbach alpha coefficient for the single dimension is calculated as 0.94. Followed by the additional validation studies, OMESS might serve as a valuable tool in order to measure self-efficacy beliefs on the use of origami in mathematics education.
Keywords. Mathematics Education, Origami, Scale Development, Self-Efficacy Beliefs

ÖZ. Bu çalışma öğretmen ve öğretmen adaylarının matematik eğitiminde origami kullanımına yönelik öz yeterlik algılarını ölçmeye yönelik bir ölçek geliştirmeyi amaçlamaktadır. Bu amaç doğrultusunda Matematik Eğitiminde Origami Öz Yeterlik Ölçeği geliştirilip, pilot çalışmada 143 öğretmen adayına uygulanmıştır. Açımlayıcı faktör analizi sonuçları tek boyutlu yapının toplam varyansın % 73'ünü açıkladığını göstermiştir. Ana çalışmada, geliştirilen ölçek 299 öğretmen adayına uygulanmıştır. Bu çalışmadan elde edilen verilerin doğrulayıcı faktör analizi ile incelenmesi sonucu RMSEA değerinin 0.068, NC değerinin 2.37, CFI ve NFI değerlerinin ise 0.99 olarak hesaplandığı görülmüştür. Ayrıca ölçekteki tek boyut için Cronbach Alfa güvenirlik katsayısı 0.94 olarak hesaplanmıştır. Başka çalışmalar ile ölçeğin geçerliliğine yönelik ilave kanıtlar sunulduğu takdirde geliştirilen bu ölçek matematik eğitiminde origami kullanımına yönelik öz yeterlik algılarını geçerli ve güvenilir bir şekilde ölçmek için kullanılabilir.
Anahtar Kelimeler. Matematik Eğitimi, Origami, Ölçek Geliştirme, Öz Yeterlik Algıları

ÖZET

Amaç ve Önem: Alanyazında origaminin matematik eğitiminde ilkokul yıllarından üniversite yıllarına, kesirler konusundan kalkülüs konularına kadar çok geniş bir yelpazede kullanılabileceği vurgulanmaktadır. Bu nedenle gerek Türkiye'de gerekse yurt dışındaki pek çok ülkede, origaminin matematik eğitiminde etkili bir şekilde kullanılmasına yönelik matematik öğretmen ve öğretmen adaylarına eğitim verilmeye başlanmıştır. Her ne kadar bu girişimler matematik öğretmen ve öğretmen adaylarının matematik eğitiminde origaminin etkili bir şekilde kullanılmasına yönelik gerekli bilgiyi edinmesi doğrultusunda olumlu olsa da, matematik eğitiminde origami kullanımına yönelik öğretmen ve öğretmen adaylarının kendilerini ne denli yeterli hissettikleri alanyazında araştırılmamıştır. Bu yönde çalışmaların yapılabilmesi için geçerlik ve güvenirlik çalışmaları yapılmış ölçeklere ihtiyaç duyulmaktadır. Bu çalışma ile origaminin matematik eğitiminde kullanılmasına yönelik öz yeterlik algılarını ölçen bir ölçek geliştirilip, geçerlik ve güvenirlik kanıtları sunulması amaçlanmıştır.

Yöntem: Origaminin matematik eğitiminde kullanılmasına yönelik öz yeterlik algılarını ölçmek amacıyla ilk aşamada alanyazının incelenmesi ve bir üniversitede verilen seçmeli origami derslerinin bir dönem boyunca gözlenmesi sonucunda geliştirilen 12 madde, matematik eğitimi ve eğitimde

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ölçme değerlendirme alanlarından iki uzman tarafından incelenmiştir. Bu aşamada uzmanların görüşleri doğrultusunda 4 madde ölçekten çıkarılmıştır. Kalan 8 maddenin öğretmen adayları tarafından anlaşılabilirliğini test etmek adına üç öğretmen adayı ile görüşmeler yapılmış ve iki maddenin yazım biçimi üzerinde ufak değişiklikler yapılmıştır. Sonrasında 8 maddeden oluşan ölçeğin son hali uzman görüşü alınabilmesi için alandan üç uzmana gönderilmiş ve onların görüşleri doğrultusunda ufak değişiklikler yapılarak ölçeğe son hali verilmiştir. Geliştirilen bu ölçek pilot çalışmada, üç farklı üniversiteden, origaminin matematik eğitiminde kullanılmasına yönelik ders almış toplam 143 ilköğretim matematik öğretmen adayına uygulanmıştır. Ölçeğin faktör yapısını belirleyebilmek için pilot çalışmadan elde edilen veriler ile açımlayıcı faktör analizi yapılmıştır. Açımlayıcı faktör analizi ile belirlenen faktör yapısını test edebilmek için ana çalışmada üç farklı üniversiteden origaminin matematik eğitiminde kullanılmasına yönelik ders tecrübesi olan 299 ilköğretim matematik öğretmen adayına ulaşılmış ve elde edilen veriler doğrulayıcı faktör analizine tabi tutulmuştur.

Bulgular: Pilot çalışmadan elde edilen verilerin açımlayıcı faktör analizi ile incelenmesinden sonra gerek öz değerler tablosu gerekse de yamaç birikinti grafiği maddelerin tek boyutta yüklendiğini göstermiştir. Bu tek boyut toplam varyansın % 73'ünü açıklamış ve ölçekteki maddelerin faktör yük değerleri de tek boyutlu yapıyı desteklemiştir. Pilot çalışmada ortaya çıkan tek faktörlü yapı ana çalışmadan elde edilen verilerin doğrulayıcı faktör analizi ile incelenmesiyle test edilmiştir. Doğrulayıcı faktör analizi sonucunda RMSEA değeri 0.068, NC değeri 2.37, CFI ve NFI değerleri de 0.99 olarak hesaplanmıştır. Ölçekteki tek boyut için Cronbach Alfa güvenirlik katsayısının 0.94 olduğu görülmüştür.

Tartışma, Sonuç ve Öneriler: Bu çalışmada geliştirilen ölçeğin detaylı madde yazım süreci, açımlayıcı ve doğrulayıcı faktör analizi sonuçlarının istenilen değerlerde olması ölçeğin geçerliği adına olumlu olarak değerlendirilmiştir. Ayrıca gerek pilot çalışmada elde edilen veriler için gerekse de ana çalışmada elde edilen veriler için hesaplanan Cronbach alfa güvenirlik katsayıları ölçeğin uygulanması ile edilen verilerin tutarlı olduğunu göstermiştir. Her ne kadar bu sonuçlar ölçeğin geçerliği ve güvenirliği için olumlu olarak değerlendirildiyse de ilerleyen çalışmalarda elde edilecek başka geçerlik ve güvenirlik kanıtlarına da ihtiyaç duyulmaktadır. Böylece bu çalışmada geliştirilen ölçek, origaminin matematik eğitiminde kullanılmasına yönelik eğitim verilen öğretmen ve öğretmen adaylarının kendilerini bu konuda ne kadar yeterli hissettiklerini anlamada ve sonuçları doğrultusunda da gerekli önlemleri almada kullanılabilir. Dahası geliştirilen bu ölçek yardımıyla matematik eğitiminde origamiyi kullanan ülkelerdeki öğretmen ve öğretmen adaylarının katılacağı karşılaştırmalı çalışmalar da yapmak mümkündür.

INTRODUCTION

Hands-on activities and concrete materials, such as tangram, might help middle school students to gain better understanding in geometry topics (Hacıömeroğlu & Apaydın, 2009; Topbaş-Tat & Bulut, 2012). Origami could be interpreted as such an activity in which students' conceptual understanding in mathematics could be enhanced. Origami is generally defined as the art of paper folding (Franco, 1999). It is possible to make different origami models such as animals, flowers, polyhedral models through folding the paper. Although origami has not originated as an educational instrument, in the advancing years, this '… ancient recreational art has come to the aid of mathematicians' (Yoshioka, 1963, p. 138). Because of the mathematically beneficial uses of origami, it started to be used in mathematics education in various ways and grade levels. For instance, a simple origami model, 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, and 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 origami paper and 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). 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 to teach some concepts 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.

The use of origami in mathematics education is not restricted to origami box model, there are also various origami models studied in the literature. For instance, in the study of Cipoletti and Wilson (2004), it is exemplified how origami pinwheel might be used to promote geometry knowledge and mathematical vocabulary of students. In another study, Hartzler (2003) mentioned how origami balloons might be used to exemplify the ratio relationships of similar solids. As exemplified with these studies in the literature, even simple origami models can be rich source for mathematics lessons in various topics and grade levels (Frigerio, 2009; Golan, 2011; Hartzler, 2003).

Apart from the mathematical benefits of origami for students, it is highly mentioned that students and also teachers have fun while doing paper folding activities in math classes (Boakes, 2009; Cipoletti & Wilson, 2004; Fiol, Dasquens, & Prat, 2011; Higginson & Colgan, 2001). However, as Georgeson (2011) stated 'Paper folding is fun but where is the math?' (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 (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. Based on this fact, some universities in Turkey began to offer elective origami courses for preservice elementary mathematics teachers since origami takes a place in national mathematics curriculum of elementary, middle, and high school grades. Although some differences appear in the programs of the universities, offered courses are generally based on classroom activities which enable students to see various mathematical effects of origami, and on introducing how to use origami as a mathematics teaching method effectively. In line with these attempts, the use of origami in mathematics education began to take attention in recent research studies in Turkey. For instance, Çakmak, Işıksal, and Koç (2014) investigated how origami-based mathematics instruction affects elementary students' spatial ability, and they found that origami-based mathematics instruction significantly increased students' spatial ability scores. In another study, it was stated that using origami activities in geometry lessons improved high school students' achievement in geometry (Arıcı & Aslan-Tutak, 2015). Attempts to train preservice teachers on the use of origami in mathematics lessons are not only restricted to Turkey. For instance, Fiol, Dasquens, and Prat (2011) mentioned how they train preservice teachers on using origami in mathematics and geometry lessons of Spanish kindergarten and primary schools. Furthermore, in Israel, Israeli Origami Centre have been training teachers more than 20 years in order to use origami as a method for the teaching of geometry in kindergarten and primary school (Golan, 2011; Golan & Jackson, 2010). Based on these trainings, in more than 35 nationwide primary schools, geometry lessons have been implemented by benefitting from origami activities (Golan, 2011). As exemplified with these examples, mathematically beneficial uses of origami have affected some preservice and in-service training programs in various countries, and they began to train preservice and/or in-service mathematics teachers on the effective use of origami in mathematics education.

Knowledge on what to do in origami-based mathematics instruction is crucial to implement origami activities effectively in mathematics lessons, and origami courses in mathematics teacher education programs or in-service training programs are promising to gain this knowledge. However, knowledge is not the only condition on the effective use of origami in mathematics lessons. Instructor's self-related beliefs work as a bridge between the knowledge and action (Pajares, 1996). Among self-related beliefs, Bandura (1986) put special emphasis on self-efficacy beliefs in order to understand and predict behavior since these beliefs might have an important effect on future performances (Pajares, 1996). In line with this point, it is possible to claim that in addition to instructors' knowledge, their self-efficacy beliefs might be highly important for the effective use of origami in mathematics education. Therefore, clarifying what self-efficacy beliefs mean, and why it is important in the context of using origami in mathematics education would be beneficial.

Self-efficacy beliefs are defined as 'beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments' (Bandura, 1997, p. 3). Self-efficacy beliefs affect the choice of behavior, and thus, people with low efficacy beliefs about a particular task tend to avoid engaging in that task, but on the other hand, people who feel highly efficacious about the task, tend to do that behavior (Bandura, 1995; Pajares & Miller, 1994). Furthermore, there is a positive relationship between one's self-efficacy beliefs about particular task and how much s/he puts effort on doing that behavior (Bandura, 1997). Therefore, one who has stronger self-efficacy beliefs would probably put more effort when compared with the ones who have low self-efficacy beliefs (Pendergast, Garvis, & Keogh, 2011; Tschannen-Moran & Woolfolk Hoy, 2001). Apart from the effect of self-efficacy beliefs on the effort expenditure while doing that behavior, it also affects how persistent one is when doing that behavior (Pajares & Kranzler, 1995; Wang, Hall, & Rahimi, 2015). People with high self-efficacy beliefs are more persistent while doing a particular task, and if they fail, they strengthen and sustain their exertion (Bandura, 1986). When the possible effects of self-efficacy beliefs are interpreted in the context of using origami in mathematics education, teachers and/or teacher candidates who have strong self-efficacy beliefs on the use of origami in mathematics education would prefer and put more effort to use origami in mathematics lessons. On the other hand, teachers and/or teacher candidates who have low self-efficacy beliefs on this issue would not prefer to implement origami-related activities in mathematics lessons. Even if they use and face with difficulties in these activities, they would probably give up implementing these activities.

Origami courses and training programs give theoretical knowledge to the preservice and/or in-service teachers regarding the use of origami in mathematics education. However, when the possible effects of self-efficacy beliefs are taken into consideration, feeling efficacious to put this knowledge into practice is also crucial on the effective use of origami in mathematics education. These possible effects of self-efficacy beliefs make essential to investigate teachers and/or teachers candidates' self-efficacy beliefs regarding the use of origami in mathematics education in order to understand their origami-related mathematics teaching decisions and practices. In order to conduct such kind of studies there is a need for valid and reliable instruments related to this issue but such scales have not been well introduced in the literature. This deficiency in the literature shaped the purpose of the current study.

In brief, it is possible to claim that there is an increasing attention on the use of origami in mathematics education because of its mathematically beneficial uses. In line with this point, there are attempts in some countries in order to train preservice or in-service teachers on the effective use of origami in mathematics education. However, there is very limited research studies conducted with preservice or in-service teachers. More specifically, in the accessible literature, there is no measuring instrument that was developed to measure preservice or in-service teachers' efficacy beliefs regarding origami. When the focus is teacher and teacher candidates, investigating their self-efficacy beliefs would yield educational benefits in terms of understanding their teaching decisions (Pajares, 1992). Therefore, the current study aims to develop and validate a scale which measures self-efficacy beliefs in using origami in mathematics education. It is believed that such a valid and reliable scale will be beneficial to conduct studies on teachers' and teacher candidates' self-efficacy beliefs on the use of origami in mathematics education and will help to eliminate the deficiency in related literature.

METHOD

Turkish Higher Education

In Turkey, the Students Selection and Placement Centre (ÖSYM) administer a national exam, and based on the scores obtained from this exam, students choose the departments of universities in which they pursue their higher education after high school. In the department of elementary mathematics education, students have to take some courses related to mathematics (e.g., calculus, discrete mathematics, linear algebra), mathematics education (e.g., methods of teaching mathematics, instructional technology and material development), pedagogy (e.g., classroom management, measurement and assessment), and moreover, there are some other must courses (e.g., Turkish, English, history). Apart from the must courses, there are also elective courses for students, and these courses might vary based on the university. Students who completed the requirements of these departments are awarded the degree of bachelor of elementary mathematics education, and they are eligible to be work as a mathematics teacher in 5th, 6th, 7th and 8th grades.

Participants

In the current study, purposive sampling method was used which enables to select the sample in accordance with the specific purpose of the study (Fraenkel & Wallen, 2006). The selection criterion in this process was preservice teachers' lesson experience on the use of origami in mathematics education. In Turkey, there are five universities which offer elective origami course for preservice elementary mathematics teachers, and in addition to these universities, one university introduces origami-based mathematics instruction through method and school experience courses. Therefore, three of these universities were used in the pilot study in order to develop the initial version of the scale, and the rest of three universities were used in the main study in order to shape the final version of the scale.

In the pilot study, Origami in Mathematics Education Self-Efficacy Scale (OMESS) was administered to 143 preservice elementary mathematics teachers from three different universities. All the preservice teachers in the pilot study had a lesson experience on the use of origami in mathematics education either through elective origami course or method and teaching practice courses.

In the main study, OMESS was administered to 299 preservice elementary mathematics teachers and details about the sample can be seen in Table 1.

Table 1. *Demographic Information on Year of Enrolment in Teacher Education Program regarding Gender*

Preservice 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
Total	211	70.6	88	29.4	299	100

As indicated in Table 1, more than ninety percent of the preservice 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 preservice teacher participated in the study. In the current study, participants were selected according to origami lesson experience. In Turkey, origami course for preservice 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. Similar to the education faculties' general 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.

In OMESS, preservice teachers are also asked about their origami experience and information about participants' answers to this question is presented in Table 2.

Table 2. *Information about Preservice 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 course	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 2, apart from origami course experience, 72 preservice teachers (24.1%) gained experience about origami-based mathematics lessons through method courses, and 61 preservice 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.

Preparation of Scale Items

The items in Origami in Mathematics Education Self-Efficacy Scale (OMESS) were developed after a detailed literature review which is based on ERIC, EBSCOhost and ULAKBİM databases. In related studies, it is seen that there are some critical issues to successfully implement origami-based mathematics activities. Planning of the origami-based mathematics lessons (Arıcı & Aslan-Tutak, 2015; Cipoletti & Wilson, 2004), choosing the appropriate origami model for the intended mathematical objectives (Golan & Jackson, 2010), and using the mathematical language properly in these activities (Cipoletti & Wilson, 2004; Hartzler, 2003) are some of these critical points. Therefore, in the item development process, all these points were taken into consideration. Apart from the studies in the literature, observations during one semester in an elective origami course offered to preservice elementary mathematics teachers, helped to develop the items in the scale. During this process, it was observed that prospective teachers' origami-based activities are expected to be in line with the curriculum, and prospective teachers are trained in this way. Therefore, some items related to the place of origami in the curriculum were also developed. In brief, based on the literature review and observations during the origami course, twelve questions were prepared in order to determine how well preservice mathematics teachers see themselves to use origami as a teaching tool in mathematics lessons. Twelve questions in the scale were firstly interpreted by two experts from educational measurement and mathematics education departments. Based on their views, four items were excluded from the scale since these items were interpreted as inappropriate for the aim of the scale. Subsequently, cognitive interviews with three preservice teachers were conducted, and some slender changes on two items were made in order to improve the comprehensibility of the items. After the cognitive interview, scale was sent to three experts who also interpreted OMESS. One of the experts was from the field of mathematics education and specialized on the affective issues in mathematics education. The other expert was from the field of science education who has several research on preservice and in-service teachers' self-efficacy beliefs. The last expert was from the field of mathematics education and has been the instructor of an origami course for many years. Based on three experts' views, slender changes on writing style were made, but there was no item deleted since experts stated that all the items are appropriate to measure preservice teachers' perceived self-efficacy beliefs in using origami in mathematics education.

All the eight items in OMESS aim to measure preservice teachers' judgment about their capability of planning and implementing of origami activities in mathematics lessons and asked at the optimal level of specificity as suggested by Bandura (1997; 2006). Items in the scale are question sentence which are not negatively worded. Furthermore, when deciding on number of points in the scale, the suggestion of Bandura (2006) was also the basis since he suggested using scales with longer number points since people don't choose the extreme points when measuring self-efficacy. Therefore, a 9 point Likert type was used in the scale in which 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. For OMESS, the lowest possible score is 8 whereas the highest possible score is 72. Sample items from the scale are demonstrated with Table 3.

Table 3. *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?

Data Analysis

The data obtained from the pilot study was analyzed with exploratory factor analysis techniques in order to explore the factor structure of OMESS. Furthermore, Cronbach alpha coefficient was calculated in order to estimate the internal consistency of data obtained through the administration of OMESS in the pilot study. After exploring the factor structure of OMESS, the data obtained from the main study was tested with confirmatory factor analysis techniques in order to cross validate the factor structure of OMESS that explored in the pilot study. Similar with the pilot study analysis procedure, Cronbach alpha coefficient was calculated in order to estimate the internal consistency of data obtained in the main study as a reliability evidence for OMESS.

RESULTS

Results of the Pilot Study

In the pilot study, exploratory factor analysis was applied by using the PASW18 statistical package program to establish the factor structure of OMESS. 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 OMESS, KMO value was calculated as 0.93 and can be interpreted as very good (Çokluk, Şekercioğlu, & Büyüköztürk, 2010). Bartlett's test of sphericity was found as significant (BTS Value = 956.07) which is desirable for the factor analysis (Büyüköztürk, 2002). These values indicated that the data set of OMESS is appropriate for factor analysis. Maximum likelihood extraction method was used since it gives the best result for normally distributed samples (Costello & Osborne, 2005).

In order to decide on factor number, both eigenvalues and scree plot are interpreted. According to eigenvalues as shown with Table 4, there is only one factor which is higher than one, and this factor's eigenvalues is quite higher than the others.

Table 4. *Exploratory Factor Analysis Results regarding Initial Eigenvalues of OMESS*

	Initial Eigenvalues		
Factor	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 1, second factor seems to be the breaking point of OMESS which can be interpreted as one factor structure is appropriate for the scale.

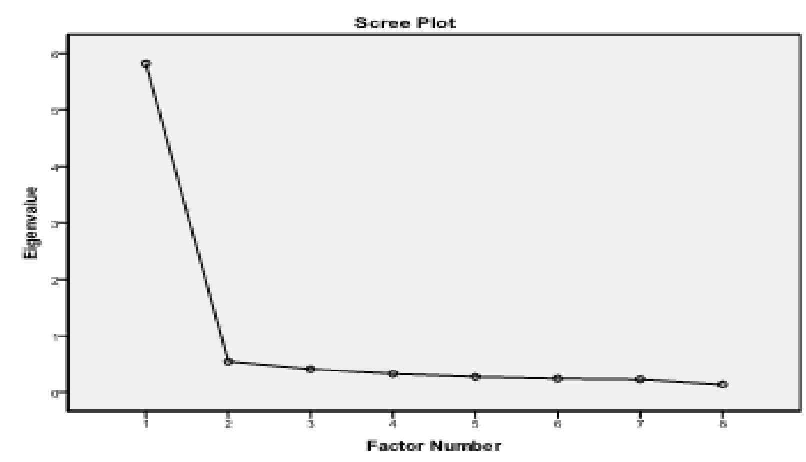

Figure 1. *Scree Plot for OMESS*

Both eigenvalues and scree plot indicated that one factor structure is appropriate for this scale. This single 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 Table 5, 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.

Table 5. *Factor Matrix of OMESS in the Pilot Study*

Item Number	How well do you feel...	Factor 1	Communality
4.	to give example about how origami can be used in mathematics education?	**.91**	0.81
7.	to make abstract mathematical concepts more concrete by using origami activities?	**.86**	0.71
6.	to choose appropriate origami model in order to gain objectives in the elementary mathematics curriculum?	**.85**	0.71
3.	to plan a mathematics lesson in which origami activities will be used?	**.84**	0.71
5.	to use mathematical language during origami activities?	**.84**	0.67
2.	to explain the place of origami in the national elementary mathematics curriculum?	**.81**	0.66
1.	to use origami effectively in mathematics lessons during your teaching years?	**.81**	0.67
8.	to find solutions to the problems of students while relating origami activity to mathematics topics?	**.71**	0.57

After deciding on the number of factors in the scale and checking their communality values and factor loadings, the single dimension of OMESS 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 the scale development process.

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

Results of the Main Study

Exploratory factor analysis results for OMESS indicated that the scale composed of one dimension which was named as perceived self-efficacy in using origami in mathematics education. In order to test this factor structure of OMESS, the scale was administered to 299 preservice elementary mathematics teachers in the main study and data obtained in the main study was analyzed with confirmatory factor analysis techniques via LISREL 8.8.

According to confirmatory factor analysis results, RMSEA value was firstly found higher than 0.10 which is interpreted as some modifications are required for the tested model, and after two modifications RMSEA value was calculated as 0.068. Hypothesized factor model of OMESS with modifications can be seen in Figure 2.

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 single dimension of OMESS and found to be 0.94. 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.

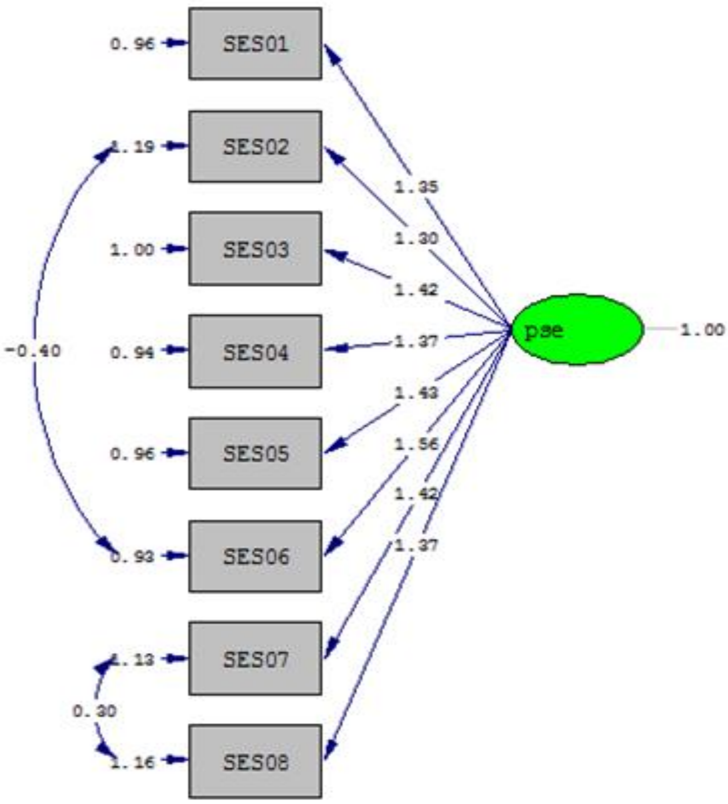

Figure 2. *Hypothesized Model and Confirmatory Factor Analysis Results of OMESS*

DISCUSSION and CONCLUSIONS

The purpose of the current study is to develop and validate a scale which measures self-efficacy beliefs in using origami in mathematics education. In line with the purpose of the current study, a detailed literature review was conducted, and also, an elective origami course for preservice elementary mathematics teachers was observed during one semester. Based on the literature review and observations, twelve items were developed in order to measure self-efficacy beliefs regarding the use of origami in mathematics education. These items were firstly evaluated by two experts, and four items were eliminated from the scale. Subsequently, interviews were conducted with three preservice elementary teachers who have a lesson experience regarding the use of origami mathematics education, and finally three experts evaluated the latest version of the scale items. These detailed item development process could be interpreted as a validity evidence for the scale (Crocker & Algina, 1986). After the item development process eight items were ready to implement in the pilot study.

According to the exploratory factor analysis, which was conducted with the data obtained from pilot study, it was decided that one factor structure is 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 indicates 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, & 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 (Pallant, 2007).

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 this value could be accepted as an evidence of a good fit (Steiger, 2007). CFI and NFI values were both calculated as 0.99; these indices 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 good fit (Kline, 2005). Establishing the factor structure of OMESS 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). Apart from the validity evidences, the Cronbach alpha coefficient was calculated for the single dimension of OMESS in order to investigate the internal consistency of the scale. Finding Cronbach alpha coefficient as 0.94 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 the current study, it should also be noted that further validity and reliability evidences are recommended for the scale.

OMESS aims to measure preservice and in-service teachers' judgments about their capability of using origami activities in mathematics lessons. It includes items related to the main points in the planning and implementation process of origami-based mathematics lessons. Therefore, OMESS can be used by teacher educators or researchers in order to measure self-efficacy beliefs of preservice and/or in-service teachers who are trained on the use of origami in mathematics education. Such studies would enable to see how efficient teachers and/or teacher candidates feel to use origami activities in their teaching practices. Furthermore, via pre-test post-test research designs, OMESS can be used to investigate how origami courses or training programs on the use of origami in mathematics education affect teachers' and teacher candidates' self-efficacy beliefs on this issue. These studies might be used as a feedback for teacher educators who design and implement courses and training programs regarding the effective use of origami in mathematics education. Furthermore, with the help of these studies, teachers and teacher candidates would also see their development, weak and strong sides on the use of origami in mathematics education.

In Turkish national mathematics curriculum, origami is interpreted as a beneficial instructional tool to be used in mathematics lessons and teachers are suggested to use origami activities in mathematics lessons. Therefore, in OMESS, apart from the items related to the planning and implementation process of origami-based mathematics instruction, there are items related to the place of origami in national mathematics curriculum. It should be beneficial to bear in mind that, when origami is not a part of the curriculum, these items should be modified according to the context of research study or should be eliminated from the scale.

Although origami is identified with Japanese culture, when the focus is using origami in mathematics education it is possible to see research studies conducted in various countries. Therefore, with the help of scales like OMESS, it is possible to conduct cross cultural studies related to origami-based mathematics instruction. Such studies would enable to see the possible cultural effects on the use of origami in mathematics education and would improve the origami-related mathematics education literature.

In brief, it is possible to claim that there is an increasing attention on the use of origami in mathematics education, but there is a lack of research conducted with teachers or teacher candidates. Therefore, it is believed that valid and reliable scales, like OMESS, would help to reach to large numbers of teachers and teacher candidates who are the crucial part in the effective origami-based mathematics lessons.

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