ATTITUDES TOWARDS PROBABILITY AND PROBABILITY TEACHING SCALE: AN ADAPTATION STUDY

Research article

Feride Özyıldırım Gümüş   0000-0002-1149-0039

Aksaray University, Turkey

ferideozyildirimgumus@gmail.com

Feride ÖZYILDIRIM GÜMÜŞ has undergraduate degree from Middle East Technical University. She started her PhD in Hacettepe University, Department of Elementary Education, at the same time worked as a research assistant. Currently, she is an Assistant Professor at Aksaray University in Turkey.

ATTITUDES TOWARDS PROBABILITY AND PROBABILITY TEACHING SCALE: AN ADAPTATION STUDY

Feride Özyıldırım Gümüş

ferideozyildirimgumus@gmail.com

Abstract

The concept of probability is an important concept to learn in school. That is why teachers and preservice teachers should learn how to teach this concept effectively. It is important and necessary to know the attitudes of teachers towards the subject of and the teaching of probability. For this reason, a scale related to the attitudes towards probability and probability teaching is adapted in this study. A quantitative research model was adopted as the research method, and data was collected from 265 prospective elementary mathematics teachers of different grade levels. After language translation of the scale items, necessary statistical analysis was conducted for the adaptation process. At the end of the study, a seven-factor scale with 27 items was obtained. There were four items in all dimensions, as in the original scale, but only three items in the behavioral component towards the teaching of probability dimension remained after the adaptation process.

Keywords: attitude, teaching probability, prospective elementary mathematics teachers

1. Introduction

The concept of probability is frequently used during decision-making processes in our daily lives, consciously and unconsciously. However, the subject of probability is one with which people experience difficulties due to various reasons (Gürbüz & Erdem, 2017). Unlike other mathematical topics, understanding probability needs deep, careful, critical and intuitive thinking, logical predictions, strong mathematical language, and rational reasoning (Gürbüz, Çatlıoğlu, Birgin, & Erdem, 2010).

Batanero, Chernoff, Engel, Lee and Sánchez (2016) state that in many countries the concept of probability is included in the curriculum of primary or secondary school mathematics. However, the grade level that the concept of probability is introduced in varies from country to country. For example, students in Turkey are first introduced to the concept of probability in their eight-grade curriculum while students in the United States and Spain are introduced to this topic at an earlier grade level. In Mexico, the introduction of probability is postponed in secondary schools, since elementary school teachers have difficulty understanding probability issues (Batanero et al., 2016).

Although the concept of probability is so important, it cannot be taught effectively in many countries due to multiple reasons (Gürbüz, Çatlıoğlu, Birgin, & Erdem, 2010). That is why understanding the attitudes that affect the teaching and learning of probability has become a critical issue. Some studies have been conducted to answer that question. For instance, Memnun (2008) investigated the factors affecting the learning of probability concepts and observed that the negative attitudes of both teachers and students toward probability are two of those factors. In addition to that, Bulut (2001) mentioned that negative attitudes towards probability, as well as inadequate equipment for the effective teaching of it, may be obstacles for successful learning and teaching of the subject. These findings demonstrate that the beliefs and attitudes of students and teachers towards the subject may play an essential role in the

teaching and learning of the concept of probability (Falk, 1989; Tversky & Kahneman, 1980). If these beliefs and intuitions are compatible with the nature of probability, students can develop their probability knowledge; otherwise, they may develop some misconceptions (İlgün, 2013).

There has been some research done on the teaching of probability and ensuring the development of positive attitudes towards probability through different teaching methods. For instance, there were studies conducted with elementary and high school students that found that different teaching methods had no significant effect on the attitudes towards probability (Bulut, 1994; Geçim, 2012; Tat, 2014; Yağcı, 2010). In these studies, it was found that attitudes towards the subject of probability do not differ according to different teaching methods.

When it comes to the teachers and prospective teachers and the concept of probability, research has mostly focused on the evaluation of probability knowledge (Batanero, Arteaga, Serrano, & Ruiz, 2014; Birel, 2017; Bulut, Yetkin, & Kazak, 2002; Kazak, & Pratt, 2017; Chernoff & Russell, 2012; Dolland; 2001; Quinn, 1997; Stohl, 2005). It was found that prospective teachers had some difficulties in teaching the concept of probability in school due to their inadequate knowledge of the subject (Quinn, 1997; Stohl, 2005). As a result, having insufficient and incorrect knowledge about the subject of probability may result in teachers and prospective teachers developing a negative attitude towards it. In addition, they do not consider probability a basic subject, although it is included in their curriculum and textbooks (Serrado, Azcarate, & Cardeñoso, 2006). This is thought to be due to the attitudes of teachers to probability, since attitude affects the learning process, as well as the strategies used in the teaching process (Aiken, 1976).

Attitude toward a concept may play an important role in the teaching process, especially for teachers. In support of this, Vartuli (2005) emphasized that the behaviors teachers exhibit during the teaching process are influenced by their thoughts and beliefs. Similarly, Heinz, Kinzel, Simon and Tzur (2000) state that teachers may have a perception about a concept and emphasize that perception to their students during the teaching process. That is why it is hardly possible for students, whose teachers have a negative attitude toward a concept, to develop a positive attitude towards that same concept (Kazemi, Shahmohammadi & Sharei, 2013). Considering that this situation may be applicable to the subject of probability, it can be assumed that teachers can transfer their attitudes towards probability to their teaching style. A teacher who has a negative attitude towards a subject may either escape from the teaching of that subject or may refer to it superficially, and as a result the students will have difficulty learning it (Gürbüz & Erdem, 2017).

1.1. Aim of the Study

Attitudes have a profound effect on the behavior of teachers and their positive attitudes may have a positive effect on their students' lives (Gourneau, 2005). That is why, beliefs and attitudes are important in the process of being an effective teacher (Wilkerson & Lang, 2007). The results of related studies support that view. For instance, Özaytabak (2004) conducted a study related to the attitudes of prospective teachers towards the subject of probability and found that their attitude toward probability is a factor that affects their decisions regarding the teaching of it. Kazemi et al. (2013) report that Kazemi et al. (2013) reports that there is a positive relationship between mathematics teachers' attitudes and the academic achievements of their students. These findings indicate that the attitudes of prospective teachers towards the teaching of probability are important since they are the teachers of the future. Having a positive attitude towards the subject of probability is important for teachers and prospective teachers to help students develop positive attitudes as well. Due to this, it is obvious that examining the

attitudes of prospective teachers towards the subject of and the teaching of probability is becoming necessary and important. To examine this, a valid and reliable scale is required.

In review of the literature, there are studies in which the attitudes of students (Bulut, 1994; Geçim, 2012; Tat, 2014; Yağcı, 2010) and prospective teachers (Bulut et al., 2002; Kazemi et al., 2013; Özaytabak, 2004) towards the subject of probability are examined. However, in those studies, general attitudes towards the subject of probability were measured with one-dimensional scales. In this study, it was determined that a scale was needed not only to measure the attitudes towards the concept of probability, but also to measure the attitudes towards the teaching of probability. A suitable scale, developed by Estrada et al. (2016), was utilized. They developed the scale for prospective teachers from all departments, rather than specifically for prospective mathematics teachers. Therefore, the findings obtained from this study should contribute to the literature.

2. Method

The scale, adaptation process and participants are discussed in details below.

2.1. Scale and Adaptation Process

For this research, a data collection tool developed by Estrada et al. (2016) was used to detect the attitudes of prospective elementary mathematics teachers towards the subject of and the teaching of probability, and the value they gave to these topics. Necessary permission to adapt the scale was received via e-mail. The scale is a Likert-type (one means strongly disagree and five means strongly agree) and consists of 28 items with seven dimensions (four items in each dimension). The first dimension is titled "affective component towards probability (AP)" rand is related to feelings about probability (items 1, 5, 16, and 27). The second dimension is titled "cognitive competence towards probability (CCP)" and is related to self-perception of probability (items 6, 8, 17, and 22). The third dimension is titled "behavioral component towards probability (BP)" and is related to inclinations to use or learn probability (items 2, 7, 15, and 18). The fourth dimension of the scale is titled "affective component towards teaching probability (AT)" which measures personal feelings related to probability teaching (items 9, 21, 26, and 28). The fifth dimension of the scale is titled "probability teaching competence component (CT)" which is about the perception prospective teachers have of their ability to teach probability (items 3, 10, 14, and 23). The sixth dimension is titled "behavioral component towards probability teaching (BT)" which measures the didactic action related to probability teaching (items 11, 20, 24, and 25). The final dimension is titled "value component towards probability and its teaching (VPT)" which is about the importance, relevance, appreciation, and usefulness of the subject of probability in addition to its teaching (items 4, 12, 13, and 19). In their pilot study, Estrada et al. (2016) calculated the reliability of the scale as .934. In their later study, Estrada et al. (2018) calculated the reliability of the whole scale as .892, in addition to the reliability values of the dimensions (AP = .759, CCP = .637, BP = .537, AT = .713, CT = .612, BT = .584, and VPT = .599) and noted that those values are at acceptable levels according to Nunnally (1978).

According to Hambleton and Patsula (1999, as cited in Gülbahar & Büyüköztürk, 2008) three stages were carried out throughout the process of adapting the scales which were cross-cultural. This study was carried out taking those stages into consideration. First, the scale items were translated from English to Turkish by the researcher, and the accuracy of the translation was evaluated by three experts in mathematics education who are studying both languages. Next, a reverse translation was done by two experts and the items were examined in terms of matching the meaning of the original ones. Second, expert opinions were taken and the consistency of the meanings of the translated scale with the original scale were examined. Due

to this examination, item 11 was omitted from the scale (according to the opinions of the experts) and the draft form of the adapted scale now consisted of 27 items. In the third and final stage, the draft form of the adapted scale was applied to preservice mathematics teachers for validity of factor structure, and the results are presented in the following section.

2.2. Participants

According to Fraenkel and Wallen (2006), it is not always possible to study samples determined by random or systematic means, so in these cases, researchers study the samples they can reach. In this study, a convenience sampling method was used. Data was collected from prospective elementary mathematics teachers from two public universities in the middle region of Turkey. The demographic information of the sample is given in Table 1.

Table 1. *Demographic information of the sample*

Variables		n	%
	female	199	80.57
Gender	male	48	19.43
	total	247	100
	freshmen	86	32.45
Grade level	sophomores	43	16.23
	juniors	71	26.79
	seniors	65	24.53
Total		265	100

As is shown in Table 1, the total number of samples differ in terms of demographic features. Some participants did not mention their genders or their grade levels. Approximately 81% of the sample is female, since females make up a large percentage of the students in education facilities in Turkey. Additionally, as participation in the study was voluntary, the lowest rate of participation came from sophomores while the highest participation rate came from freshmen.

3. Results

For the adaptation process of the scale, the first confirmatory factor analysis was conducted through the linear structural relations program. Once the data was collected, the original seven-factor structure was tested through confirmatory factor analysis and the values obtained are presented in Table 2.

Table 2. *Confirmatory factor analysis results*

	$\chi 2$/sd	p	NNFI	AGFI	GFI	CFI	RMSEA
Model 1	2.82	.00	.94	.80	.85	.95	.077
Model 2	2.98	.00	.94	.81	.85	.95	.072

As is demonstrated in Table 2, the values of model 1, (which are the same as the original scale apart from item 11), such as AGFI (.80), GFI (.85), and RMSEA (.077) are calculated.

Since the RMSEA value is higher than the accepted value, a second model was conducted in order to reduce the RMSEA value. Due to this, an error covariance was applied between item 1 and item 5 in model 2. Values for model fit are found to be sufficient in model 2 according to related literature (Anderson & Gerbing, 1984; Cole, 1987; Kline, 2011; Marsh et al., 1988). The structure of model 2 is given in Figure 1.

The calculated reliability of the scale is .92. That is higher than the original scale, and most of the dimensions are also higher than the original scale (AP = .85, CCP = .60, BP = .68, AT = .74, CT = .69, BT = .54, and VPT = .61). When the reliability values are examined in detail, they are noted to be at appropriate levels per Nunnally (1978). However, the BT dimension, which had the lowest reliability value in the original scale, was observed to be even lower here. Nunnally and Bernstein (1994) mention that if the test is too short, the Cronbach alpha value will be lower. This may be due to the omission of item 11 from the scale, as it belonged to the BT dimension in the original scale. After the adaptation process, there were four items in all dimensions (like the original scale) except the BT dimension, which only had three. After the adaptation process was completed, the distribution of scale items to factors was calculated and the results are shown in Table 3.

Table 3. *Items and factors of adapted scale*

| Factors	Items
Affective component towards probability (AP)	1, 5, 16, 27
Cognitive competence towards probability (CCP)	6, 8, 17, 22
Behavioral component towards probability (BP)	2, 7, 15, 18
Affective component towards teaching probability (AT)	9, 21, 26, 28
Teaching probability competence component (CT)	3, 10, 14, 23,
Behavioral component towards teaching probability (BT)	20, 24, 25
Value component towards probability and its teaching (VPT)	4, 12, 13, 19
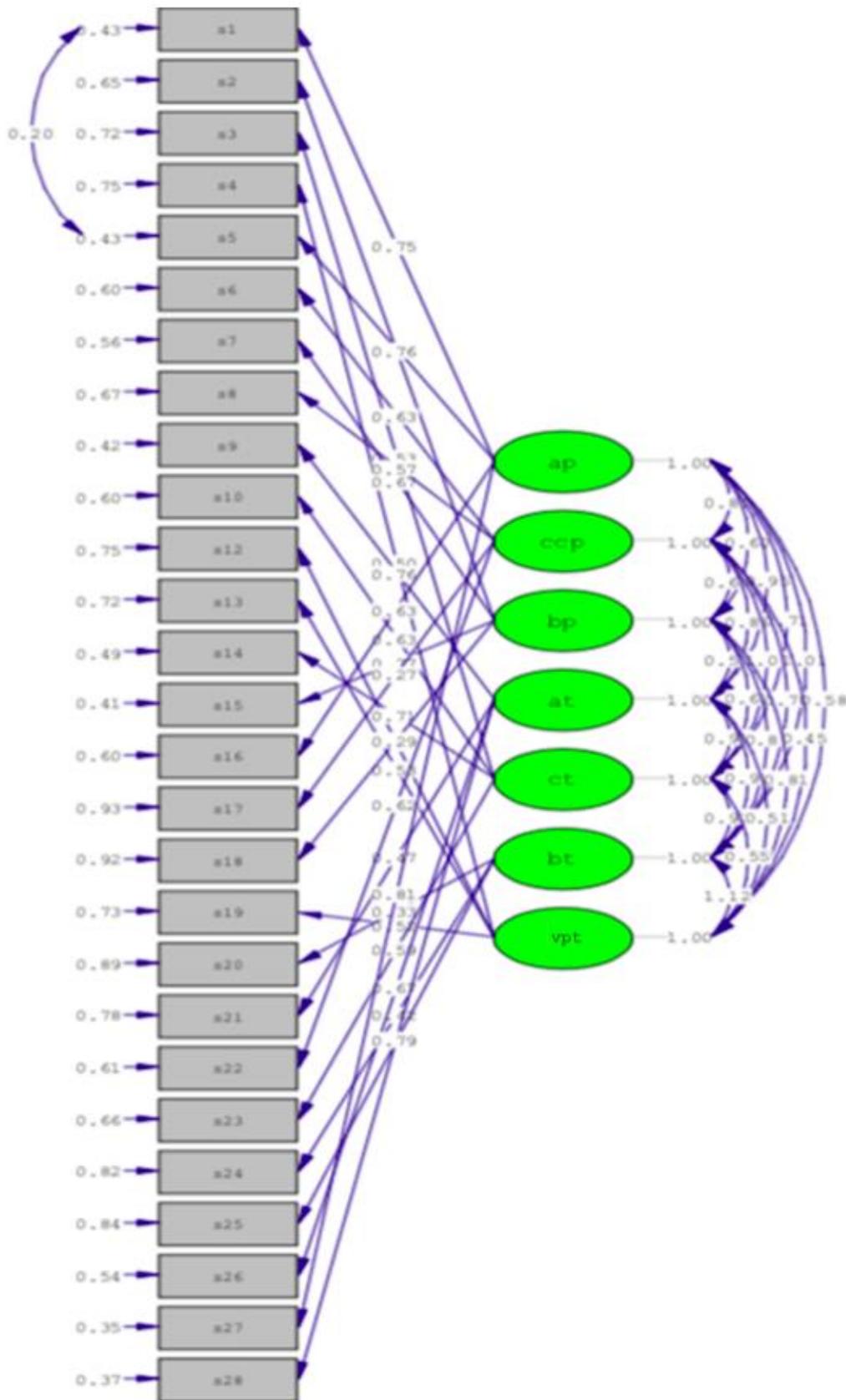
Figure 1. Confirmatory factor analysis model for the structure of model 2

4. Discussion and Conclusions

Although the subject of probability is intertwined with daily life, there are various problems in the learning of and the teaching of it. For example, teacher-centered education and the lack of using materials in classes (Pijls et al., 2007) are two of those problems. Additionally, Gal and Garfield (1997) state that negative attitudes and beliefs have an impact on learning and teaching processes, and this may partially be the reason why probability is confusing and complicated for students and teachers. Due to this, determining the attitudes of prospective elementary mathematics teachers (who are the teachers of the future) towards probability and its teaching has become an important issue. To determine these attitudes, it was necessary to develop a scale that could be used in the teachers' native language.

Although there is some research related to attitudes towards probability, it is limited. This is especially true regarding studies about the attitudes of prospective teachers towards teaching probability. This is why determining the attitudes towards teaching probability, in addition to attitudes about the concept of probability, will strengthen related literature and assist with teacher self-development. For both current and prospective teachers, being aware of their own attitudes towards a concept will support their professional development. However, the number of measurement tools available to detect attitudes towards teaching probability was not adequate. With the scale adapted within the scope of this study, it is now possible to measure the attitudes teachers have towards the teaching of and the subject of probability.

Determining the attitudes of current and prospective teachers towards the teaching of probability is important since they can affect the attitudes and the learning of students. To assist with improving attitudes in the future, seminars could be arranged for teachers, and courses related to probability and probability teaching could be added to the undergraduate curriculum for prospective teachers.

References

Aiken, L. R. (1976). Update on attitudes and other affective variables in learning mathematics. *Review of Educational Research, 46*(2), 293-311.

Anderson, J. C., & Gerbing, D. W. (1984). The effect of sampling error on convergence, improper solutions, and goodness of fit indices for maximum likelihood confirmatory factor analysis . *Psychometrika, 49*(2), 155-173.

Batanero, C., Arteaga, P., Serrano, L., & Ruiz, B. (2014). Prospective primary school teachers' perception of randomness. In E. Chernoff, & B. Sriraman (Eds.), *Probabilistic thinking: Presenting plural perspectives* (pp. 345–366). New York: Springer.

Batanero, C., Chernoff, E. J., Engel, J., Lee, H., & Sánchez, E. (2016). Research on teaching and learning probability, ICME-13. Topical Survey series. In *Research on teaching and learning probability* (pp. 1-33). New York: Springer.

Birel, G. K. (2017). The Investigation of Pre-service Elementary Mathematics Teachers' Subject Matter Knowledge About Probability. *Mersin University Journal of The Faculty of Education, 13*(1), 348-362.

Bulut, S. (1994). *The effects of different teaching methods and gender on probability achievement and attitudes toward probability.* (Doctoral Dissertation). Middle East Technical University, Ankara, Turkey.

Bulut, S. (2001). Investigation of Performances of Prospective Mathematics Teachers on Probability. *Hacettepe University Journal of Education, 20*, 33-39.

Bulut, S., Yetkin, İ. E., & Kazak, S. (2002). Investigation of Prospective Mathematics Teachers' Probability Achievement, Attitudes Toward Probability and Mathematics with Respect to Gender. *Hacettepe University Journal of Education*, 22, 21-28.

Chernoff, E. J., & Russell, G. L. (2012). The fallacy of composition: Prospective mathematics teachers' use of logical fallacies. *Canadian Journal of Science, Mathematics and Technology Education, 12*(3), 259–271.

Cole, D. A. (1987). Utility of confirmatory factor analysis in test validation research. *Journal of Consulting and Clinical Psychology, 55*, 584-594.

Dolland, C. (2011). Preservice Elementary Teachers and the Fundamentals of Probability. *Statistics Education Research Journal, 10*(2), 27-47.

Estrada, A., Batanero, C., Comas, C. & Díaz, C. (2016). Exploring Teachers' Attitudes Towards Probability and Its Teaching. Paper presented at the *13th International Congress on Mathematical Education*, Hamburg, July 24-31.

Estrada, A., Batanero, C., & Díaz, C. (2018). Exploring Teachers' Attitudes Towards Probability and Its Teaching. In C. Batanero, & E. J. Chernoff (Eds.), *Teaching and Learning Stochastics: Advances in Probability Education Research* (pp. 313-332). Cham, Switzerland: Springer International Publishing.

Falk, R. (1989). Inference under uncertainty via conditional probabilities. *Studies in mathematics education: The Teaching Of Statistics, 7*, 175-184.

Fraenkel, J. R., & Wallen, N. E. (2006). *How to design and evaluate research in education.* New York, NY: McGraw-Hill.

Gal, I., & Garfield, J. B. (1997). *The Assessment Challenge in Statistics Education.* Amsterdam: IOS press.

Geçim, A. D. (2012). *The effect of creative drama-based instruction on seventh grade students' mathematics achievement in probability concept and their attitudes toward mathematics* (Master Thesis). Middle East Technical University, Ankara, Turkey.

Gourneau, B. (2005). Five Attitudes of Effective Teachers: Implications for Teacher Training. *Essays in education, 13*(8), 1-8.

Gülbahar, Y., & Büyüköztürk, Ş. (2008). Adaptation of Assessment Preferences Inventory to Turkish. *Hacettepe University Journal of Education, 35*, 148-161.

Gürbüz, R., & Erdem, E. (2017). Middle School Mathematics Teachers' Views on the Challenging Reasons for Learning of Probability Subject. *Journal of Social Sciences of Mus Alparslan University, 5*(2), 361-380.

Gürbüz, R., Çatlıoğlu, H., Birgin, O., & Erdem, E. (2010). An investigation of fifth grade students' conceptual development of probability through activity based instruction: a quasi-experimental study. *Educational Sciences: Theory & Practice, 10*(2), 1021-1069.

Heinz, K., Kinzel, M., Simon, M. A., & Tzur, R. (2000). Moving students through steps of mathematical knowing: An account of the practice of an elementary mathematics teacher in transition. *Journal of Mathematical Behavior, 19*(1), 83- 107.

İlgün, M. (2013). *An Investigation of Prospective Elementary Mathematics Teachers' Probabilistic Misconceptions and Reasons Underlying These Misconceptions* (Doctoral Dissertation). Middle East Technical University, Ankara, Turkey.

Kazak, S., & Pratt, D. (2017). Pre-Service Mathematics Teachers' Use Of Probability Models In Making Informal Inferences About A Chance Game. *Statistics Education Research Journal, 16*(2), 287-304.

Kazemi, F., Shahmohammadi, A., & Sharei, M. (2013). The survey on relationship between the attitude and academic achievement of in-service mathematics teachers in introductory probability and statistics. *World Applied Sciences Journal, 22*(7), 886-891.

Kline, R. B. (2011). *Principles and practice of structural equation modeling.* New York: The Guilford Press.

Marsh, H. W., Balla, J. R., & McDonald, R. P. (1988). Goodness-of-fit indexes in confirmatory factor analysis: The effect of sample size. *Psychological Bulletin, 103*, 391-410.

Memnun, D. S. (2008). Difficulties of Learning Probability Concepts, the Reasons Why These Concepts Cannot be Learned and Suggestions For Solution. *Inonu University Journal of the Faculty of Education, 9*(15), 89-101.

Nunnally, J. C. (1978). *Psychometric theory.* New York: McGraw-Hill.

Nunnally, J. C., & Bernstein, I. H. (1994). *Psychometric Theory.* New York: McGraw Hill.

Özaytabak, E. (2004). *Factors affecting preservice mathematics teachers' decisions on probability teaching.* (Master Thesis). Middle East Technical University, Ankara, Turkey.

Pijls, M., Dekker, R., & Van Hout-Wolters, B. (2007). Reconstruction of a collaborative mathematical learning process. *Educational Studies in Mathematics, 65,* 309-329.

Quinn, R. J. (1997). Effects of mathematics methods courses on the mathematical attitudes and content knowledge of preservice teachers. *The Journal of Educational Research, 91*(2), 108-114.

Serrado, A., Azcarate, P., & Cardeñoso, J. M. (2006). Analyzing teacher resistance to teaching probability in compulsory education. Retrieved from https://pdfs.semanticscholar.org/32d4/833ef3f95ba6bbf1697dbb0bee8e8113193f.pdf

Stohl, H. (2005). Exploring probability in schools: Challenges for teaching and learning. In G. Jones (Ed.), *Probability in teacher education and development* (pp. 345-366). New York: Springer.

Tat, T. E. (2014). *The effect of conceptual change based instruction on tenth grade students' understanding of probability concepts, probability achievement and attitudes toward probability.* (Doctoral Dissertation). Middle East Technical University, Ankara, Turkey.

Tversky, A., & Kahneman, D. (1980). Causal schemas in judgments under uncertainty. *Progress in social psychology, 1*, 49-72.

Vartuli, S. (2005). Beliefs: The heart of teaching. *Young Children, 60*, 76-86.

Wilkerson, J. R., & Lang, W. S. (2007). *Assessing teacher dispositions.* Thousand Oaks, CA: Press.

Yağcı, F. (2010). T*he Effect of Instruction With Concrete Models On Eighth Grade Students' Probability Achievement and Attitudes Toward Probability.* (Master Thesis). Middle East Technical University, Ankara.