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Research Article

Examination of the relationship between pre-service teachers' attitudes towards uncertainty, probability and its teaching

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The purpose of this study was to determine how pre-service elementary mathematics teachers' attitudes towards uncertainty and probability and its teaching vary by their year of education and gender. A relational survey model was implemented in accordance with the quantitative paradigm. There were 212 participants in the study, which used a maximum diversity sampling method. We used the independent sample t-test, one-way analysis of variance (ANOVA), and Pearson's product-moment correlation analysis. Compared to female pre-service teachers, male pre-service teachers had lower negative attitudes towards uncertainty. In the affective component, there was a significant difference in favor of male pre-service teachers, while in the behavioral component, there was a significant difference in favor of female pre-service teachers towards teaching probability, and in the value component, it was significant in favor of female pre-service teachers. According to the year of education, significant differences were found. Additionally, pre-service teachers' attitudes towards probability, its teaching, and uncertainty were weakly correlated (r =.212, p <.01). We suggest reorganizing the curriculum on the basis of axiomatic reasoning with an understanding of the uncertainty in life, and that this symbolism should extend to other disciplines as well as mathematics.

Keywords: Content knowledge, teacher training, randomness

Uncertainty, in the presence of vivid hopes and fears, is painful, but must be endured if we wish to live without the support of comforting fairy tales.
Bertrand Russell

1. Introduction

1.1. Attitude towards Uncertainty

Everywhere we go, including the classroom and our everyday lives, we encounter randomness. We need to understand randomness in order to make intelligent decisions about our lives, such as choosing investments or medical treatments (Batanero & Serrano, 1999). As Liu (2013) points out, objective randomness and human uncertainty are both present in a system simultaneously.

The word "uncertainty" refers to two related concepts: data and chance. It is not a mathematical issue, but both phenomena can be studied mathematically. Statistics and probability are mathematical disciplines that deal with data and chance (Moore, 1990). The type of uncertainty depends on the mathematical theory used to formalize the issue situation. There is a subset of uncertainties that can only be accounted for by each formal theory. In general, the more general a theory is, the more types of uncertainty it can account for. The traditional mathematical theories for describing uncertain circumstances are set theory and probability theory (Klir, 1995). In Knight's (1965) definition, uncertainty is a situation in which the probability distribution is unknown. Griffiths and Wall (2000) defined uncertainty as knowing that a given situation could have more than one outcome, but not knowing the probability of each outcome. In measuring uncertainty, both error and variance are taken into account (İğdeli & Sever, 2018). Several factors affect making the right decision in daily life situations, including uncertainty (Pange & Talbot, 2003). As a result, reasoning under uncertainty is associated with probabilistic reasoning (Savard, 2014). As described by Falk (1989), we quantify the uncertainty about the target event as a conditional probability. In his explanation, he explained how uncertainty and probability are related.

Considering how individuals make choices in the face of ambiguous probabilities in real-life circumstances, we think it is crucial to examine how the outcome domain influences this response (Di Mauro & Maffioletti, 2004). As a result of their own experience in making decisions under uncertainty, people differentiate between prospects with clear probability estimates and prospects for which probabilities are unclear and for which they feel less competent (Abdellaoui, et al., 2010). Probabilities that are clearly known are considered to be risk (for example, the likelihood that a coin will land on tails in a toss), while probabilities that are completely unknown are considered ambiguous (for example, the probability that it will rain tomorrow).

It is crucial to recognize how intricately intertwined all aspects of uncertainty are. Preconceptual (data), conceptual (proxies), and symbolic levels of uncertainty (concepts), for example, influence subjective assessments of the knowledge domain (Gärdenfors 2004). According to Marzetti and Scazzieri (2011), human preferences or fickleness cause complex feedback among the parts of socio-ecological systems, which ultimately influences decision-making (Pe'er et al., 2014).

Psychological uncertainty is more effective than attempting to comprehend or forecast decisions (Windschitl & Wells, 1996). Uncertain circumstances cause people to experience high levels of stress and tension. When the brain interprets this as a danger warning, adrenaline is released. The term *state of uncertainty* refers to an occurrence that occurs unexpectedly and unexpectedly, disrupts daily life in a number of different ways, undermines current social and individual functioning, and generally affects an individual's attitude and triggers a crisis. A person's attitude is his or her reaction to a given situation (Park & Burgess, 1921). It is therefore very important to determine individuals' attitudes toward uncertainty.

1.2. Attitudes towards Probability and Its Teaching

Probability theory is essentially a formalization of how people naturally perceive chance, which leads to the concept of allocating numbers to uncertain events (Batenero, et al., 2016). When faced with uncertainty, probabilistic reasoning refers to assessments and decisions made in everyday life, such as when evaluating risks (Falk & Konold, 1997).

It is important for teachers to use these intuitive concepts to assist students in developing a more mature understanding of probability and comparing the likelihood of different events in a world filled with uncertainty. Numerous educational authorities have acknowledged the need to comprehend random phenomena and to make appropriate decisions under uncertain circumstances. Therefore, probability instruction is included in the curriculum of many nations' primary and secondary schools. However, the success of proposed curricula directly depends on how enthusiastic and eager teachers are about teaching the subject matter (Estrada & Batanero, 2020). Teachers' attitudes towards probability and its teaching come to mind here. According to Batanero et al. (2016), there is a lack of research on probabilistic thinking and reasoning in teacher education. Researchers have also rarely examined instructors' perceptions of randomness and probability (Elbehary, 2020; Hourigan & Leavy, 2020). The majority of mathematics instructors learn only theoretical probability (Kvatinsky & Even, 2002), which means they have little formal experience dealing with scenarios involving randomness and uncertainty. Moreover, it is often believed that teaching randomness and probability is challenging because they are counterintuitive (Batanero et al., 2014; Eichler & Vogel, 2014; Kazak & Pratt, 2021).

Based on their beliefs about themselves and the content, pre-service teachers will respond positively or negatively to a stochastic learning scenario (Estrada & Batanero, 2020). If the same kind of emotional reaction (disappointment, satisfaction, etc.) is produced by repeating the situation in question several times, this can become an attitude (Gómez-Chacón, 2010). Phlipp

(2007) defines attitude as the ways of acting, feeling, or thinking that show one's temperament or vision. Like emotions, attitudes can contain positive or negative emotions but are felt with less intensity than emotions. Negative attitudes can affect teachers' willingness to consider the study of statistical content summarized in the curriculum and their willingness to improve their understanding of the content (Goldin et al., 2016; Hannigan, Gill & Leavy, 2013; Nasser, 2004; Zientek et al., 2011).

In their study on probability and attitudes towards its teaching, Estrada and Batanero (2015) analyzed attitudes using a seven-component model. Teachers' and prospective teachers' attitudes toward probability are evaluated in the first three components of their model. Three other components assess attitudes towards the didactic aspects of probability. The last component describes the value given to probability and its teaching and aspects directly related to it.

Affective component towards probability (AP). This evaluates the subject's personal feelings towards probability, such as liking/dislike towards this subject, fear/confidence when starting to work or problem solving, interest in/indifference to the subject, and positive or negative feelings towards probability. This component is taken into account in the attitudes towards statistics scales.

Cognitive competence towards probability (CCP). In probability, it assesses one's perception of one's own capacity, knowledge, and intellectual abilities. It is also seen in attitude scales towards statistics, because when a subject likes a subject, it is possible that he finds it difficult or thinks he has little capacity for that subject. It will be important for a teacher to have a good sense of his or her ability to teach a particular subject.

Behavioral component towards probability (BP). This evaluates the tendency to use probability, making decisions, helping other colleagues, and use of probability.

Affective component towards teaching probability (AT). This involves personal feelings for teaching probability, which can vary with the affective component (though relevant) to the topic. This component measures like/dislike, fear/trust, and interest/indifference towards probability teaching.

Teaching probability competence component (CT). This evaluates the perception of one's own skills in teaching, solving student difficulties, suggesting good tasks, searching for resources, etc. A teacher may think that learning a subject is easy, but may or may not think this is enough to teach it.

Behavioral component towards teaching probability (BT). This evaluates the tendency towards didactic action: if the teacher tries or has tried to teach probability or has not taught it, gives priority over other subjects, or thinks that it should generally be postponed.

Value component towards probability and its teaching (VPT). The value, usefulness, and relevance that the teacher attaches to probability in personal and professional life and to the student's education on this subject, namely the inclusion of probability teaching in the curriculum, is evaluated.

2. Literature Review

2.1. Literature on Attitudes towards Uncertainty

Studies on attitudes towards uncertainty examine the relationships between attitudes toward uncertainty and attitudes toward randomization (Dominiak & Schnedler, 2011) and attitudes toward risk (Shou & Olney, 2020). Ahsanuzzaman et al. (2018) uncovered that Bangladeshi farmers behave differently when the probability distribution of an uncertain prospect is known versus when it is not. Yılmaz (2023) examined the relationship between university students' perceived uncertainty levels before and after the pandemic and their decision-making behaviors according to various demographic characteristics (gender, age, year, and department of education). There was a significant, positive, and medium level relationship between uncertainty levels and decision-making behaviors.

2.2. Literature on Attitudes towards Probability and Its Teaching

In studies on attitudes towards uncertainty, the relations between attitudes towards uncertainty and attitudes towards randomization (Dominiak & Schnedler, 2011) and attitudes towards risk (Shou & Olney, 2020) are examined. Ahsanuzzaman et al. (2018) highlighted that generally Bangladeshi farmers behave differently when the probability distribution of an uncertain prospect is known, compared to a scenario where it is not known. Yılmaz (2023) examined the relationship between university students' perceived uncertainty levels before and after the pandemic and their decision-making behaviors according to various demographic characteristics (gender, age, year, and department of education). The relationship between uncertainty levels and decision-making behaviors was significant, positive, and medium level.

Using the same scale used in the present study, Alvarado et al. (2018) analyzed attitudes towards probability and its teaching in 70 secondary school mathematics teachers and 51 pre-service secondary school mathematics teachers in Chile. Although the participants had a positive attitude, the teachers were slightly more positive than the pre-service teachers. In addition, attitudes did not differ based on gender or educational level. Further, Ruz Molina-Portillo et al. (2020) examined the attitudes of 126 pre-service mathematics teachers in Chile and Spain towards probability. According to the findings, they have a positive attitude towards the subject. A prospective early childhood educator's attitudes towards probability and its teaching were examined by Vasquez Ortiz et al. (2019). Based on the results, attitudes towards statistics and statistics teaching were slightly more positive than attitudes toward probability and probability teaching, and attitudes towards probability and probability teaching were generally somewhat negative. However, Estrada and Batanero (2020) in their study examining the attitudes of 416 pre-service primary school teachers towards probability and its teaching showed that these teachers understand the value of probability and its teaching, and they feel that they are not well prepared for teaching the subject. According to Salifu and Dokurugu (2022), in their study examining the relationship between attitudes towards statistics and attitudes towards probability among 300 pre-service teachers in Ghana, both attitudes towards statistics and attitudes toward probability were positive among pre-service teachers. In addition, Estrada et al. (2018) analyzed 232 pre-service teachers in Spain using the scale they developed to measure their attitudes toward probability. Based on the study, teachers' attitudes towards probability and its teaching were generally positive across all components.

It is important for teachers to have a positive attitude toward a concept during the teaching process. In support of this, Vartuli (2005) emphasized that teachers' behavior is influenced by their beliefs and thoughts. In this context, it has been considered necessary to examine the attitudes of teachers who play a key role in the teaching process in this context, and the attitudes towards uncertainty may be related to attitudes towards probability and its teaching. As a result of this situation, we will be able to examine how uncertainty (a reality in life) is related to mathematics and its teaching. In this research, we will examine how uncertainty in life is related to probability and its teaching, which requires a mathematical understanding. In terms of probability and its teaching, it is extremely important, since it examines whether there is a relationship between coping with uncertainty in life and attitudes toward probability and its teaching, based on the idea that no study has examined the relationship between those attitudes and attitudes toward probability and its teaching. In reviewing the literature, it was concluded that examining the relationship between individuals' attitudes towards uncertainty and probability and its teaching, which examines uncertainty as a discipline, was worthwhile.

As part of this purpose, the following problem statement was developed: Is there a significant relationship between pre-service mathematics teachers' attitudes towards uncertainty, their attitudes towards probability, and their teaching in terms of their gender and year of education? The study sought to answer the following research questions:

RQ 1) Do pre-service mathematics teachers' attitudes towards uncertainty differ according to gender and year of education?

RQ 2) Do pre-service mathematics teachers' attitudes towards probability and its teaching differ according to gender and year of education?

RQ 3) Is there a relationship between prospective mathematics teachers' attitudes towards uncertainty and their attitudes towards probability and its teaching?

3. Method

3.1. Research Design

The purpose of this quantitative study was to determine the relationship between pre-service teachers' attitudes toward uncertainty and their attitudes toward probability. The study was conducted using a correlational survey model. A correlational study examines the relationship between two or more covariate variables without attempting to influence them. It is extremely complex to determine and study human behavior in both individual and social contexts. Relational research attempts to identify these complex relationships (Neuman, 2006).

3.2. Instruments

The attitudes towards uncertainty scale, developed by Ersanlı and Uysal (2015), and *the attitudes towards probability and its teaching scale*, developed by Estrada and Batanero (2015), were used as data collection tools. The attitudes towards uncertainty scale, which has a single factor structure, consists of 15 items. The internal consistency coefficient of the scale, which had a five-point Likert-type design, was given as α =.89. The internal consistency coefficient of the scale was calculated as α =.94 for this study.

The attitudes towards probability and its teaching scale is five-point Likert-type scale and consists of seven factors, namely the affective component towards probability (AP), cognitive competence towards probability (CCP), behavioral component towards probability (BP), affective component towards teaching probability (AT), teaching probability competence component (CT), teaching behavioral component towards probability (BT), and value component towards probability and its teaching (VPT). The reliability coefficient of the scale was given as α =.892. The internal consistency coefficient of the scale was calculated as α =.879 for this study. Table 1 shows the reliability coefficients (Cronbach's alpha) calculated by Estrada and Batanero (2015) for the scale and the scale items in the factors.

Table 1
The attitudes towards probability and its teaching scale's factors

Factors	*Cronbach's Alpha*	*The Scale Items*
Affective component towards probability (AP)	.759	1, 5, 16, 27
Cognitive competence towards probability (CCP)	.637	6, 8, 17, 22
Behavioral component towards probability (BP)	.537	2, 7, 15, 18
Affective component towards teaching probability (AT)	.713	9, 21, 26, 28
Teaching probability competence component (CT)	.612	3, 10, 14, 23
Behavioral component towards teaching probability (BT)	.584	11, 20, 24, 25
Value component towards probability and its teaching (VPT)	.599	4, 12, 13, 19

3.3. Sampling or Study Group

The study group consisted of pre-service teacers in the first, second, third and fourth grades of the Primary Mathematics Teaching Program at four state universities located in the Central Black Sea, Western Black Sea and Central Anatolia Regions in Türkiye during the 2022-2023 academic year. Since the study involved all students enrolled in the Elementary Mathematics Teaching Program, maximum diversity sampling was performed. Moreover, convenience sampling was used since the chosen study group was close and easily accessible. Data were collected via an online survey from pre-service teachers for the 2022–2023 academic year using *the attitudes towards uncertainty scale* and *attitudes towards probability and its teaching scale*. Prior to the online data collection, the researchers thoroughly explained the survey to the pre-service teachers. Demographic information about the study group is summarized in the tables.

Table 2
Distribution of mathematics pre-service teachers by gender

Variable (Gender)	*Frequency*	*Percentage*
Female	166	78.3
Male	46	21.7
Total	212	100

Table 2 shows that of the 212 pre-service teachers participating in the research, 78.3% were female (n=166) and 21.7% were male (n=46). Table 3 shows the descriptive statistics of pre-service teachers by year of education.

Table 3
Distribution of mathematics pre-service teachers by year of education

Variable (year)	*Frequency*	*Percentage*
1st Year	52	24.5
2nd Year	57	26.9
3rd Year	52	24.5
4th Year	51	24.1
Total	212	100

Of the 212 pre-service teachers, 52 (24.5%) were in the first year, 57 were in the second (26.9%), 52 were in the third (24.5%), and 51 were in the fourth (24.1%).

3.4. Data Analysis

The significance level in the current study's data analysis, which was conducted using SPSS 22, was set at 0.05. The distributions of the participant's gender and year of education were calculated using descriptive statistics like frequency (f) and percentage (%). The Kolmogorov–Smirnov normality test was used to determine which tests would be used in the data analysis. The results revealed that the dataset was not normally distributed and that the p values for the *attitudes towards uncertainty scale* and the *attitudes towards probability and its teaching scale* were less than the significance level of 0.05. The normality distribution was examined according to the skewness and kurtosis values for each variable using the values given by George and Mallery (2010), taking into account that values between −1.5 and +1.5 (Tabachnick & Fidell, 2013) or between -2.0 and +2.0 (George & Mallery, 2010) indicate a normal distribution. Eight pre-service teachers' data with extreme values were removed from the dataset after the extreme values in the data group were identified using a box plot chart in SPSS. As a result, each variable was considered to be "normally distributed" within itself because all of the skewness and kurtosis values acquired throughout the study fell within the normalcy range. Pearson's product moment correlation analysis (see Table 4) was adopted in response to this finding.

Based on these normally distributed scales, the mean total scores and mean sub-dimension scores were analyzed using the *t*-test for independent samples. When there were more than two years of education on these normally distributed scales, mean total scale scores and mean subscale scores were compared through one-way analysis of variance (ANOVA) in accordance with year of education. The LSD test was used to identify the group causing the significant difference between the groups.

For the statistics of the study, effect sizes were calculated. While calculating these effect sizes, the Cohen's *d* calculation technique used considering Thalheimer and Cook's (2002) classification. Therefore, an effect size of 0.15 was considered as negligible, 0.4 as small, 0.75 as medium, 1.10 as

Table 4
Pearson's product moment correlation analysis

Sub-dimensions and overall totals	*n*	*Min*	*Max*	*Mean*	*SD*	*Skewness*	*Kurtosis*
Uncertainty	212	15.00	73.00	37.43	13.16	.432	−.311
AP	212	4.00	20.00	12.73	3.35	−.431	−.326
CCP	212	4.00	19.00	12.89	2.34	−.355	.585
BP	212	5.00	20.00	14.87	2.29	−.973	1.347
AT	212	5.00	20.00	13.69	2.52	−.309	.273
CT	212	7.00	20.00	13.36	2.19	−.283	.120
BT	212	8.00	19.00	14.64	1.83	−.458	.442
VPT	212	11.00	20.00	16.4	1.99	−.359	−.134
Probability	212	63.00	133.00	98.61	11.96	−.173	.088

large, 1.45 as very large, and values greater than 1.45 were considered as huge. Cohen's *d* statistic is a type of effect size. An effect size is a specific nonzero numerical value used to represent the degree to which a hypothesis is false. As an effect size, Cohen's *d* is typically used to represent the magnitude of differences between two (or fewer) groups on a particular variable, with larger values representing greater differentiation between two groups on that variable (Becker, 2020). The uncertainty scale and the probability and probability teaching scale were examined among male and female pre-service teachers according to their subdimensions.

3.5. Procedure

This study examined how individuals' attitudes about uncertainty and probability and its teaching relate. A five-step analysis was conducted on the research's data.

1) Data were gathered and prepared for statistical analysis. Skewness and kurtosis values were considered in SPSS to determine whether the data had a normal distribution.

2) Eight pre-service teachers with extreme data values in the box plot constructed using SPSS were excluded from the evaluation, although the study originally included 220 pre-service teachers; 212 future teachers were included.

3) The mean and standard deviation (SD) scores of all subscales were calculated based on the frequency and percent (%) values of the participants' demographic data.

4) The Kolmogorov–Smirnov test was used to verify the assumption of normal data distribution before evaluating the *attitudes towards uncertainty scale* and *the attitudes towards probability and its teaching scale* based on various demographic characteristics. Because the normal distribution was below the .05 level of statistical significance, kurtosis and skewness measures were applied. Based on the kurtosis and skewness scores, the distribution was linear. In this regard, parametric testing was used. A statistical significance level of .05 was considered. In this context, a *t*-test for independent groups was used to determine whether the subscale scores of the students in the sample group differed by gender. The subscale scores of the sample group of students were compared by year of education using ANOVA. LSD and Scheffé's tests were used to identify groups with significant ANOVA-induced differences.

5) In order to determine the correlation between the *attitudes towards uncertainty scale* and the subscales of the *attitudes towards probability and its teaching scale*, Pearson's product-moment correlation analysis was used.

4. Findings and Discussion

4.1. Findings related to First Research Question

In the study, the first research question was whether pre-service mathematics teachers' attitudes towards uncertainty differ according to gender and year of education. The data indicating normal distribution was analyzed with the independent samples *t*-test to determine if there was a statistically significant difference between the *attitudes towards uncertainty scale* total scores of the pre-service teachers according to gender. The results are shown in Table 5.

Table 5
t-test results of attitudes towards uncertainty scale according to gender

	n	*Mean*	*SD*	*t*	*p*
Uncertainty					
Female	166	35.98	12.85	−3.110	.002*
Male	46	42.67	13.08		

Note. *p <.05

The independent samples t-test revealed a significant difference between the groups with a moderate effect value (Cohen's d = 0.516). There is a significant difference in uncertainty scores between male and female pre-service teachers ($t(275)=-3.11$; p <.05). The attitude toward uncertainty of male pre-service teachers (Mean=42.67) is higher than that of female pre-service teachers (Mean=35.98). Therefore, it can be concluded that male pre-service teachers tolerate uncertainty higher than female pre-service teachers.

A one-way ANOVA was used to determine whether there was a statistically significant difference between pre-service teachers' *attitudes towards uncertainty scale* total scores that were normally distributed according to their year of education. The results are presented in Table 6.

Table 6
The comparison of prospective teachers' attitudes towards uncertainty scale by year of education

	n	*Mean*	*SD*	*F*	*p*	*Scheffé's TV*	*LSD TV*
Uncertainty							
1st year	52	37.11	14.29	1.373	.252	-	2-4 years*
2nd year	57	39.61	12.25				
3rd year	52	38.15	13.51				
4th year	51	34.6	12.42				

Note. TV: Test-value; *p <.05 .

According to Table 6, the means of the total scores in different classes do not differ statistically significantly ($F_{3,208}$ = 1.373; p >.05). While Scheffé's test analysis did not reveal a significant difference between groups, the LSD test revealed a significant difference of .05 between the second and fourth years in uncertainty.

4.2. Findings related to Second Research Question

The second research question was whether pre-service mathematics teachers' attitudes towards probability and its teaching vary by gender and year of education. In order to examine whether there was a statistically significant difference between pre-service teachers' *attitudes towards probability and its teaching scale*'s sub-dimensions and total mean scores by gender, an independent samples t-test was conducted. The results are shown in Table 7.

Table 7 shows that the difference between the mean sub-dimensions of the scale [Affective component towards probability ($t(275)=-2.579$; p <.05), BT ($t(275)$ = 3.298; p <.01), and *value* component towards probability and its teaching ($t(275)$= 3.857; p <.00)] was statistically significant according to gender.

There was a statistically significant difference (Cohen's d = 0.398) in favor of the male teacher candidates for the *affective* component towards probability sub-dimensions in the group averages. According to the analysis, the mean *affective* component towards probability (Mean=13.69) of the male pre-service teachers was higher than that (Mean=12.46) of the female pre-service teachers. There was a statistically significant difference (Cohen's d = 0.542) in favor of the female teacher candidates for the *behavioral* component towards teaching probability ($t(275)$ = 3.298; p <.01) and *value* component towards probability and its teaching ($t(275)$ = 3.857;

Table 7
t-test results of attitudes towards probability and its teaching scale according to gender

	n	*Mean*	*SD*	*t*	*p*
Affective component towards probability					
Female	166	12.46	3.48	−2.57	.011*
Male	46	13.69	2.64		
Cognitive competence towards probability					
Female	166	12.78	2.41	−1.267	.206
Male	46	13.28	2.00		
Behavioral component towards probability					
Female	166	14.87	2.32	.026	.979
Male	46	14.86	2.17		
Affective component towards teaching probability					
Female	166	13.69	2.51	.007	.994
Male	46	13.69	2.58		
Teaching probability competence component					
Female	166	13.40	2.18	.509	.611
Male	46	13.21	2.22		
Behavioral component towards teaching probability					
Female	166	14.85	1.76	3.298	.001**
Male	46	13.86	1.89		
Value component towards probability and its teaching					
Female	166	16.67	1.85	3.857	.000***
Male	46	15.43	2.16		
Probability					
Female	166	98.77	12.17	.353	.724
Male	46	98.06	11.29		

Note. *p<.05; **p<.01;***p<.001

$p < .00$) sub-dimensions in the group averages. According to the analysis, the mean *behavioral* component towards teaching probability (14.85) of the female pre-service teachers was higher than that (Mean=13.86) of the male pre-service teachers. Similarly, the female pre-service teachers' *value* component towards probability and its teaching (Mean=16.67) averages were significantly (Cohen's d= 0.616) higher than those of the male teacher candidates (Mean=15.43). No significant difference existed between the male and female teacher candidates in other sub-dimension scores or overall total scores [Cognitive competence towards probability ($t(275)=-1.267$; $p > .05$), *behavioral* component towards probability ($t(275)= .26$; $p > .05$), *affective* component towards teaching probability ($t(275)=.007$; $p > .05$), Teaching probability competence component ($t(275)=.509$; $p > .05$), *probability* ($t(275)= .353$; $p > .05$)].

One-way ANOVA was conducted to determine whether there was a statistically significant difference between the pre-service teachers' *attitudes towards probability and its teaching scale*'s sub-dimension mean scores and the total mean scores by year of education. Table 8 shows significant differences in some of the *attitudes towards probability and its teaching scale*'s sub-dimension and total score averages among the prospective teachers in different years of education [(Affective component towards probability ($F_{3,208} = 2.196$; $p > .05$), *cognitive* competence towards probability ($F_{3,208} = 1.761$; $p > .05$), Teaching probability competence component ($F_{3,208} = 1.724$; $p > .05$)]. While the Scheffé's test analysis performed to know between which groups there was difference showed only a significant difference of 0.05 between first and third year students in *teaching* probability competence component, the LSD test revealed a significant difference of 0.05 between third and fourth year students and between first and fourth year students in *affective* component towards probability and between first and third year students in *cognitive* competence towards probability, between first and third year students in *teaching* probability competence component, and between

Table 8
The comparison of prospective teachers' Attitudes towards Probability and Its Teaching by year of education

	n	*Mean*	*SD*	*F*	*p*	*Scheffé's TV*	*LSD TV*
AP							
1st year	52	12.34	3.13	2.964	.033*	-	3-4 years*
2nd year	57	13.38	3.07				1-4 years*
3rd year	52	13.34	3.36				
4th year	51	11.78	3.66				
CCP							
1st year	52	12.51	2.62	3.235	.023*	-	1-3 years*
2nd year	57	13.1	2.33				3-4 years**
3rd year	52	13.59	2.34				
4th year	51	12.33	2.26				
BP							
1st year	52	14.82	2.25	.628	.598	-	-
2nd year	57	14.71	2.25				
3rd year	52	15.25	2.04				
4th year	51	14.72	2.61				
AT							
1st year	52	13.55	2.67	1.559	.200	-	-
2nd year	57	13.94	2.41				
3rd year	52	14.11	2.34				
4th year	51	13.13	2.63				
CT							
1st year	52	13.09	2.00	3.071	.029*	3-4 years*	1-3 years*
2nd year	57	13.47	2.04				3-4 years**
3rd year	52	14.03	2.15				
4th year	51	12.82	2.42				
BT							
1st year	52	14.36	1.96	2.209	.088	-	2-3 years*
2nd year	57	14.29	1.95				
3rd year	52	15.00	1.69				
4th year	51	4.94	1.62				
VPT							
1st year	52	16.28	2.13	.467	.706	-	-
2nd year	57	16.22	2.06				
3rd year	52	16.63	1.81				
4th year	51	16.49	1.96				
Probability							
1st year	52	97.00	11.47	2.448	.065	-	1-3 years*
2nd year	57	99.15	12.31				3-4 years*
3rd year	52	101.98	10.99				
4th year	51	96.23	11.96				

Note. TV: Test-value. **p* <.05; ***p* <.01;****p* <.001

second and third year students in *behavioral* component towards teaching probability. The LSD test also showed a significant difference of 0.01 between third and fourth year students in *cognitive* competence towards probability and between third and fourth year students in *teaching* probability competence component.

4.3. Findings related to Third Research Question

The third research question of the study was whether a relationship exists between prospective mathematics teachers' attitudes towards uncertainty and their attitudes towards probability and its teaching. Pearson's product moment correlation analysis was carried out to determine whether there was a significant relationship between the participants' attitudes towards probability and its teaching and their attitudes towards uncertainty. The results are shown in Table 9.

Table 9
Pearson's product moment correlation analysis

	1	2	3	4	5	6	7	8	9
1. AP	1								
2. CCP	.615***	1							
3. BP	.459***	.395***	1						
4. AT	.722***	.678***	.436***	1					
5. CT	.639***	.684***	.418***	.733***	1				
6. BT	.191**	.189**	.209**	.282***	.216**	1			
7. VPT	.259***	.227**	.430***	.327***	.248***	.351***	1		
8. Probability	.831***	.779***	.670***	.862***	.805***	.441***	.534***	1	
9. Uncertainity	.178**	.270***	.105	.250***	.312***	−.033	−.093	.212**	1

Note. ***p* <.01; ****p* <.001

According to Table 9, pre-service teachers' attitudes regarding probability and uncertainty are weakly positive (r =.212, p <.001). Participants' attitudes toward probability and its teaching were moderately correlated. A weak positive correlation was found between pre-service teachers' attitudes toward uncertainty and the *attitudes toward probability and its teaching scale*'s *affective* component towards probability, *cognitive* competence towards probability, *affective* component towards teaching probability, and *teaching* competence component sub-dimensions. There was a low correlation between attitudes towards uncertainty and the *attitudes towards probability and its teaching scale*'s *affective* component towards probability (r =.178, p <.01), while attitudes toward uncertainty were strongly correlated with *teaching* probability competence (r =.312, p <.01).

5. Discussion

In this study, we examined the relationship between pre-service elementary mathematics teachers' attitudes towards uncertainty, probability, and its teaching in relation to their year of education and gender.

In analyzing data obtained from pre-service teachers, it was found that male pre-service teachers had lower negative attitudes towards uncertainty than female pre-service teachers. Similar findings have been reported by Uysal (2015) that female university students have a significantly higher attitude toward uncertainty scores than males. Karataş and Uzun (2018) found that female university students are less tolerant of uncertainty than male students. The number and amount of money wagered by boys in grade school is already higher than that of girls (Ladouceur et al., 1994). Boys can demonstrate courage in a social environment by playing games of chance involving money, according to Griffiths (1989). There might be differences between the gambling behavior of boys and girls as a result of this. One of the reasons for this is that, in general, these games lead individuals' probabilistic thinking understanding to question the deterministic context (Savard, 2010; Serrado et al., 2005). In some artificial gambling situations, Savard (2010) investigated primary school students' probabilistic thinking, reporting that they used deterministic reasoning.

Among pre-service teachers, when the attitudes towards probability and its teaching were compared based on gender, it was found that the affective component towards probability score was significantly different for males, whereas the behavioral component towards teaching probability and the value component towards probability and teaching scores were significantly different for females.

Affective component towards probability is related to attitudes towards probability, whereas behavioral component towards teaching probability is related to attitudes towards didactic aspects of probability. In relation to probability and its teaching, the value component refers to the value placed on probability and its teaching as well as related aspects. In contrast to the results obtained with the affective component toward probability score, Bulut et al. (2002) found that there was no significant difference between the mean attitudes of females and males toward probability in their study of pre-service mathematics teachers. The findings of Alvarado et al. (2018) are also in agreement with the finding that male teachers have a slight improvement in attitude towards probability only by three points when compared to female teachers. A study by de Oliveira Junior et al. (2018) examined students' attitudes toward probability and statistics courses based on their utility, anxiety, confidence, pleasure, and motivation. They found that students lack confidence when it comes to solving statistical and probabilistic problems. Despite not feeling anxious, they lack confidence when it comes to solving probabilistic and statistical problems.

Research on the concept of probability with teachers and pre-service teachers focuses on evaluating their knowledge of probability (Batanero et al., 2014; Kazak & Pratt, 2017; Stohl, 2005). Accordingly, the fact that male teacher candidates have a higher Affective component towards probability score can be explained by the fact that men play certain games of chance more often than women (Carneiro et al., 2020; Wong et al., 2013).

Pre-service teachers' attitudes towards uncertainty were not significantly different based on their year of education. According to the analyses performed according to year of education, there is a significant difference between the Affective component towards probability, cognitive competence towards probability, and teaching probability competence component sub-dimensions. First and third year students had higher averages in the affective component towards probability sub-dimension than fourth year students. Further, the third-year students had higher mean scores in the cognitive competence towards probability sub-dimension than the first- and fourth-year students. Lastly, third-year students had higher averages in the Teaching probability competence sub-dimension than first- and fourth-year students. Analyses conducted according to year of education revealed significant differences in affective component towards probability, cognitive competency towards probability, and teaching probability competence component sub-dimensions. First and third year students had higher averages in the affective component towards probability sub-dimension than fourth year students. Furthermore, third-year students scored higher on the cognitive competence towards probability sub-dimension than first- and fourth-year students. Lastly, students in the third and fourth years had higher averages in the sub-dimension of teaching probability competence. There was no significant difference in the BT sub-dimension, but the third-year averages were higher than the second-year averages. Morever, while no significant difference was detected in probability, third-year students had higher averages than first- and fourth-year students. This suggests that the reason for the high teaching probability competence component subscale in the third year students may be the probability teaching course they take that year. Guinez et al. (2021) reported that interactive stories (Alice in Randomland) can improve primary school teacher candidates' attitudes towards probability and teaching. Furthermore, while there was no significant difference in the teaching probability competence component sub-dimension, the third year averages were higher than the second year averages. Similarly, third-year students had higher averages than first- and fourth-year students in probability, although there was no significant difference.

On the other hand, a weak positive relationship was found between pre-service teachers' attitudes towards the uncertainty scale and the affective component towards probability, cognitive competence towards probability, affective component towards teaching probability, and teaching probability competence component sub-dimensions of the attitudes towards probability and its teaching scale. According to Şenol and Akdağ (2018), pre-service teachers' attitudes towards uncertainty and their motivation to teach it are moderately negative and significant. In that study, however, all pre-service mathematics teachers in their fourth year were considered. Due to the fact that the current study examines the relationship between probability and its teaching, and uncertainty is the determinant on the basis of probability theory, it can be concluded that there is no parallelism in the results.

Finally, a weak positive correlation has been found between the pre-service teachers' attitudes towards uncertainty scale and the attitudes towards probability and its teaching scale's affective component towards probability, cognitive competence towards probability, affective component towards teaching probability, and teaching probability competence sub-dimensions.

5. Educational Implications and Future Directions

Students who will be mathematics teachers in Türkiye in the near future participated in the present study. Before entering the teacher training program, many of them had similar teaching backgrounds and are building the teaching knowledge they need on top of what they know from their undergraduate studies. Considering the findings of the study in the context of correctly associating the uncertain nature of life with the mathematical relationship, the following suggestions are presented:

Review of probability lesson design in teacher education: Candidates for teacher positions are enrolled in higher education institutions and can be evaluated as adults. Accordingly, Bloom's taxonomy is not sufficient, and Fink's taxonomy should be considered when planning the courses. Consequently, teachers should receive probability teaching courses that are closely related to the probability courses they are taking in their training programs, and probability content knowledge should be designed in a manner that allows the uncertain nature of life to be expressed symbolically.

A review of probability teaching at the K12 level: Mathematical programs in many countries rarely address probability gains. In this context, it is recommended that policy makers in the field of education restructure the curriculum on the basis of the axiomatic context in order to imply the uncertainty in life, and that this symbolic relationship between uncertainty and mathematics be established in other disciplines as well.

Conducting research in a qualitative context: A qualitative, longitudinal, and in-depth study of the relationship between tolerance for uncertainty in life and learning is recommended.

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