# DETERMINANTS OF SECONDARY SCHOOL TEACHERS' ATTITUDES TOWARDS PROBABILITY AND ITS TEACHING

ANE IZAGIRRE
*University of the Basque Country (UPV/EHU)*
*ane.izagirre@ehu.eus*

JON ANASAGASTI
*University of the Basque Country (UPV/EHU)*
*jon.anasagasti@ehu.eus*

AINHOA BERCIANO
*University of the Basque Country (UPV/EHU)*
*ainhoa.berciano@ehu.eus*

## ABSTRACT

*Probability literacy has gained importance in educational curricula. The aim of this research was to analyse secondary education teachers' attitudes towards probability and its teaching and to examine differences across the factors of gender, academic training, and work experience. From a positivist paradigm, a quantitative methodology was used. The sample consisted of 185 in-service teachers, and the instrument used was the Attitudes Towards Probability and Its Teaching questionnaire. The results suggested that gender had no effect on teachers' attitudes, but having a mathematics background was associated with a relevant weight on teachers' attitudes. Work experience presented a medium effect on the behavioural aspect of the teaching probability dimension, with better attitudes among teachers who had more work experience. This led us to acknowledge the importance of disciplinary knowledge in both initial and continuing training.*

***Keywords:*** *Statistics education research; Probability literacy; Attitudes; Secondary education; In-service teachers*

## 1. INTRODUCTION

Statistics and probability literacy have become increasingly valued in recent decades due to their usefulness in everyday life as well as in professional settings (Guiñez et al., 2021). This increased value implies the need to train students in the classroom so that they can apply their acquired knowledge in the future. Teachers play an essential role in this endeavour because they must be qualified to teach statistical and probabilistic concepts in the most effective way; effective teaching of probability requires appropriate teacher preparation (Batanero et al., 2016). The cognitive aspects to take into account are content knowledge, didactic content knowledge, and pedagogical knowledge (Shulman, 1986). However, teachers' affective aspects (beliefs, motivation, and emotions) are also considered to be important for instruction (McLeod, 1992) because they have a relevant impact on teaching practices and student learning (Huber et al., 2024). In this sense, Batanero and Álvarez-Arroyo (2024) recently conducted a systematic review of the studies carried out in recent years on the teaching and learning of probability. They pointed out the need for more research to analyse teachers' attitudes towards probability and its teaching in general, but there is a particular need to analyse attitudes beyond preschool and primary school teachers and pre-service teachers. For all these reasons, in this paper, our aim is to inform the community's knowledge about in-service secondary school teachers' attitudes towards probability and its teaching because probability is a subject that generally receives little attention in the classroom (Alvarado et al., 2018; Anasagasti et al., 2024). Because probability in today's society is increasingly useful, we believe it is important to explore this issue of attitudes to identify determining factors that might help to change this tradition of low dedication.

*Statistics Education Research Journal, 24(2). https://doi.org/10.52041/serj.v24i2.751*

Researchers conducting work in the area of teacher affect have argued for its importance with regard to various identified factors associated with affect (Alvarado et al., 2018; McLeod, 1992). In particular, Alvarado and colleagues (2018) identified specific personal variables (gender, in-service or pre-service teacher, and years of service) and school variables (type of establishment and level of education) as important to consider. Of the variables mentioned, we have attended to gender and duration of work experience. Gender is defined as a socio-cultural construct by which capabilities, roles, expectations, behaviours, and values are assigned to people simply because of the mere fact of being born male or female (Carraza et al., 2008). In this sense, Ruz et al. (2023) stated that gender-sensitive research was essential in probability because it was a fundamental part of the disciplines covered by STEM (Science, Technology, Engineering, and Mathematics), where the gender gap was widening (Petroff et al., 2021). The duration of a teacher's work experience is an important variable to investigate because studies indicated that student performance increases with teaching experience (Topchyan & Woehler, 2021). We found studies that highlighted the importance of teachers' years of experience in relation to their values regarding mathematics education (Dede, 2013), the value they place on the subject (Jacobs & Spangenberg, 2014), and their teaching knowledge (Copur-Gencturk & Li, 2023). It is worth asking whether teachers' attitudes towards probability and its teaching are linear or, on the contrary, may have stops, starts, and regresses over the years.

The academic training of teachers was another variable that we considered in this study because, according to research carried out in the European framework (Becker et al., 2014; Hill et al., 2005), it was an important variable that influenced the learning process of students. Becker et al. (2014) highlighted the close relationship between teachers' academic background and the quality of student learning. One of the main problems in Spain since the 1980s has been the lack of teachers with training in mathematics and the reliance on a heterogeneous workforce made up of people with studies in diverse fields (Muñiz-Rodríguez et al., 2016). In Spain, each autonomous community establishes legislation for access to the mathematics teaching profession, although they all follow similar lines. Focusing on the regulations of the Community of the Basque Country (ACBC), we see that, on the one hand, the requirements to participate in the selective procedures of the competitive examinations for secondary education and vocational training are to hold a university degree and a master's degree in secondary education (Basque Government, Department of Education, 2020). On the other hand, if we analyse regulations pertaining to the qualification of candidates for temporary teaching staff needs in public non-university ACBC centres (high schools/secondary schools; Basque Government, Department of Education, 2012), we find that qualifications such as architecture, engineering, geology, biology, environmental sciences, etc. are allowed. This reality, i.e., the fact that the teaching staff have little training in mathematics in general and in statistics and probability in particular, may have an impact on teacher's attitudes.

In this context, there is a need for research that examines teachers' attitudes and beliefs about probability (Batanero & Álvarez-Arroyo, 2024; Guiñez et al., 2021). Therefore, our study addressed the following research questions:

1. What are the attitudes towards probability and its teaching of in-service secondary education mathematics teachers in the ACBC region?
2. Do the attitudes of in-service teachers towards probability and its teaching differ across factors such as gender, academic training, and work experience?

With the exception of the study by Alvarado et al. (2018), most studies focused on teacher affect in relation to probability carried out descriptive analyses of the scales used (as detailed in Section 2) without considering independent variables of a demographic (gender and age), anthropological (educational, social, and instrumental), or pedagogical (affective, cognitive, and behavioural) nature. Therefore, in this study, we took into account the complementary variables of gender, academic training, and work experience and analysed teachers' attitudes towards probability and its teaching on an inferential basis. In this way, we set out to identify factors in teachers' attitudes that can condition the teaching and learning of probability in order to improve the situation in the classroom.

## 2. ATTITUDES TOWARDS PROBABILITY

To teach probability content in addition to other areas of mathematics, mathematics teachers must be able to master the subject (Batanero et al., 2016), but the cognitive aspect is not the only important aspect that should be considered for teachers to be effective. McLeod and McLeod (2002) emphasised the impact of affect on the teaching-learning process in mathematics. The Mathematics Teacher's Specialised Knowledge (MTSK) model also includes the domain of teachers' beliefs and conceptions about mathematics and its teaching-learning together with the domains of mathematical and didactic-mathematical knowledge (Carrillo et al., 2018). The Onto-Semiotic Approach takes affective suitability into account, although it considers that affect is necessarily interconnected with cognition (Beltrán-Pellicer et al., 2018). On the other hand, Marbán (2016) remarked that the affective domain joins various subdomains that are differentiated from the purely cognitive ones. Because the principal point of interest is the teacher, we find that we must consider attitudes towards mathematics together with attitudes towards the teaching of mathematics.

Our interest is specific to the case of statistics and probability. The first instruments to measure attitudes towards statistics and probability appeared in the 1980s, and they were designed exclusively to measure attitudes towards statistics. According to Carmona (2004), the most commonly used instruments are the *Statistics Attitude Survey* (Roberts & Bilderback, 1980), *Attitudes Toward Statistics* (ATS; Wise, 1985), *Attitudes towards Statistics Scale* (Auzmendi, 1992), *Survey of Attitudes Toward Statistics* (Schau et al., 1995), and *Attitudes towards Statistics Scale of Estrada* (EAEE; Estrada, 2002). The latter is the only one that includes pedagogical and anthropological components beyond the subject-related components per se. Subsequently, due to the lack of tools to measure attitudes towards probability and after detecting the need for an instrument to measure attitudes towards probability and its teaching, Estrada and Batanero (2015) designed and validated the *Attitudes towards Probability and its Teaching Scale* (hereafter ASPT). Following Wyer and Albarracín (2014), they identified three components of attitudes (affect, behaviour, and cognition) and related them to probability (see Table 1) within the dimension labelled Attitudes towards Probability (Dimension 1, abbreviated as DIM. 1). Because the scale was designed for teachers, attitudes towards didactic aspects of probability were also assessed by considering affective, cognitive, and behavioural components within the dimension labelled as Attitudes towards the Teaching of Probability (Dimension 2, abbreviated as DIM. 2). Finally, Estrada and Batanero (2015) also included a dimension for appreciation of the subject and its teaching consisting of a single value component (Dimension 3, abbreviated as DIM. 3). See the description of each component for each dimension in Table 1.

*Table 1. ASPT scale dimensions, components, and descriptions (Estrada et al., 2016, p. 5; Ruz et al., 2023, p. 6)*

| Dimension | Component | Description |
|---|---|---|
| DIM. 1. Attitudes towards probability | Affective (AP) | Feelings about probability |
| | Cognitive competence (CP) | Self-perception concerning self-competence, knowledge, and intellectual skills |
| | Behavioural (BP) | Inclinations to act towards the attitude object in a particular way, to make decisions in situations involving the attitude object, to help colleagues to learn and use probability |
| DIM. 2. Attitudes towards the teaching of probability | Affective (AT) | Personal feelings about teaching probability, which may differ from feelings towards the topic itself |
| | Teaching competence (CT) | Teacher's perception of his/her ability to teach probability, to help students, to pose effective tasks, etc. |
| | Behavioural (BT) | Whether the teacher has or has not taught probability, whether he/she gives priority over other topics, and whether he/she thinks the topic should be postponed or given emphasis |
| DIM. 3. Value towards probability and its teaching | Value (VPT) | Appreciation of the usefulness, relevance, and importance of probability and its teaching in personal and professional life. |

Estrada et al. (2016) conducted a pilot study in which the ASPT questionnaire was administered to 71 trainee teachers in primary education. Both for the global scale and for each component, the mean score exceeded the neutral score (a value of 3 on the scale). Among the research papers that reported on studies of attitudes towards probability and its teaching using the ASPT scale, Alvarado et al. (2018) was the only one that analysed these attitudes according to different variables, albeit only descriptively. The variables considered were the following: type of teacher (in-service or pre-service), type of establishment (municipal, subsidised, or public school), gender (male or female), and teaching experience (1–3 years, 4–5 years, 6–11 years, or more than 11 years). The results indicated better attitudes among in-service teachers than pre-service teachers, among teachers belonging to subsidised schools than teachers belonging to municipal or public schools, and among men than women. In terms of teaching experience, they observed that teachers' attitudes increased as their years of teaching increased. Among studies that carried out inferential analyses, results have only been reported for the gender variable. For example, Estrada and Batanero (2020) analysed a sample of 416 pre-service primary school teachers and concluded that attitudes towards probability (DIM. 1) are significantly better among men than women, whereas no significant differences between men and women were observed for the other two dimensions. These results coincided with those of Ruz et al. (2023), who considered 269 pre-service mathematics teachers and only observed significant differences in attitudes towards probability, with a greater predisposition among men than women.

The paucity of studies that carried out an inferential analysis of the ASPT scale to analyse the factors associated with attitudes led us to consider potential factors identified in research that used instruments to measure attitudes towards statistics. Gil Flores (1999) did not find significant differences with respect to gender when applying the ATS to 654 university students pursuing a degree in pedagogy. They also concluded that the attitudes of students with a baccalaureate in science were significantly higher than those of students with a baccalaureate in literature. Estrada et al. (2004) used the EAEE with 140 teachers and concluded that there were significant differences in attitudes based on the number of statistics subjects the teachers had previously studied but not for gender. In addition, they mentioned that in-service teachers' attitudes worsened as their years of experience increased. Martins et al. (2015) administered the EAEE to 1098 Portuguese teachers of students in grades 1 through 6 (ages 6–12) of basic education. In terms of gender, they did not find significant differences; however, they did obtain significant differences with regard to teaching experience and training. Better attitudes were found among teachers who had been teaching for more than two years. Therefore, in this study, we identified gender, years of work experience, and academic background as important variables to consider and analysed their effect on teachers' attitudes.

## 3. METHODOLOGY

This research follows a positivist research paradigm in that attitudes towards probability and its teaching are inferred from a quantitative approach (Godino, 2010). More specifically, this study is mainly inferential, although a descriptive summary is provided to show the type of sample we had at the attitudinal level (Hernández et al., 2014).

### 3.1. SAMPLE AND ANALYSED CONSTRUCTS

The questionnaire for the study was sent to all the secondary school management teams in the Autonomous Community of the Basque Country (ACBC) for distribution to mathematics teachers. Thus, the study had the potential to include all secondary education mathematics teachers in the ACBC. The final sample consisted of 185 teachers who completed questionnaires, of whom 110 were women (59.5%), 72 were men (38.9%), and three (1.6%) chose an "other" option. Questionnaires from the latter three people were not considered in analyses due to the small number. The mean age of the participants was 44.51 years (SD = 10.72 years). With regard to the participation of secondary education schools in the ACBC, the questionnaire was answered by 29.79%, 34.56%, and 24.88% of the centres in Araba, Gipuzkoa, and Bizkaia (the three provinces of the ACBC), respectively, representing 16.4% of mathematics teachers in the ACBC (Basque Government, Department of Education, 2021).

In addition to gender, the constructs of academic training and work experience were considered. Categories for academic training were defined based on the responses received. The experimental sciences category was the most heterogeneous and included participants with backgrounds in biology, geology, pharmacy, and chemistry. Seven total categories were defined and are presented along with their abbreviations and their corresponding absolute and relative frequencies as follows: mathematics (Math; 56; 30.27%), physics (Phys; 10; 5.41%), engineering (Eng; 59; 31.89%), experimental sciences (ExpSci; 41; 22.16%), architecture (Arch; 11; 5.95%), economics (Econ; 6; 3.24%), and primary education (PrimEd; 2; 1.08%). The category of primary education was not considered in the analysis due to the small number of people in these studies. According to the curricula of the universities of the ACBC, apart from the mathematics degree, individuals pursuing physics and economics degrees studied the most mathematics, including statistics and probability. The type of engineering degree pursued determined the exact coursework requirements, but it was common to find requirements of only one course in calculus, a second in algebra, and a third in statistical methods in engineering. The latter was a 60-hour course that included combinatorics, probability, and descriptive statistics. In the case of computer scientists, operations research was a required 60-hour course that included linear algebra, linear programming, duality, branch and bound algorithms, the transport problem, and heuristic optimisation. Experimental science degrees required two mathematics subjects: biostatistics or mathematics and statistics, in which probability was taught, as well as descriptive statistics. Architecture degrees also required two mathematics courses that included elements of algebra, geometry, and calculus but no training in statistics and probability.

For work experience, we collected data for the number of years teachers taught secondary mathematics, which equalled the number of years they taught probability because the curriculum of the ACBC has included probability in all secondary education courses since the beginning of this millennium. Work experience was divided into five intervals that were set before the questionnaire was administered. The setting of these intervals was discussed by the three authors and the intervals were considered appropriate for identifying differences in attitudes due to an aging teacher workforce. The intervals and the corresponding absolute and relative frequencies follow: five or fewer years ($(0, 5]$; 56; 30.27%), more than five years but 10 or fewer years ($(5, 10]$; 27; 14.6%), more than 10 years but 15 or fewer years ($(10, 15]$; 20; 10.8%), more than 15 years but 20 or fewer years ($(15, 20]$; 18; 9.7%), and more than 20 years ($(20, \infty)$; 64; 34.6%).

### 3.2. INSTRUMENT

The ASPT scale designed by Estrada and Batanero (2015) was used to measure teachers' attitudes. The questionnaire was adapted to incorporate more inclusive language and to address in-service teachers. For example, item 3 in Appendix A was adapted to become *it is difficult for me to teach probability* for in-service teachers currently teaching probability instead of *it will be difficult for me to teach probability* in the original version of the questionnaire. It was also translated into Basque using a validation process by bilingual experts in the area of mathematics teaching (see Anasagasti et al. (2023) for details about the validation process). The questionnaire is included in Appendix A. The questionnaire consists of 28 items, with some phrased in the affirmative and some phrased in the negative form to avoid the problem of acquiescence, whereby some participants tend to choose a response of agreement regardless of the content of the item.

For validation, Estrada and Batanero (2015) subjected the questionnaire to evaluation by expert judges. A list of 56 items was submitted to 14 experts (statisticians, mathematicians, psychologists, and statistics educators), who provided a numerical value for the adequacy of each item for the intended component; the four highest-scoring items in each component were selected for the questionnaire. The item numbers associated with each component are displayed in Table 2.

For the data obtained in this study, we applied Bartlett's sphericity test to check if there was a correlation between items (Shrestha, 2021). We obtained a $p$-value $< .001$ (Chi-square value of approximately 2231.83), which allowed us to reject the null hypothesis that the correlation matrix was an identity matrix, indicating no correlation among items, and conclude that the items of the scale are correlated with each other. We then calculated the Kaiser-Meyer-Olkin sampling adequacy measure to determine the degree of commonality between items (Shrestha, 2021). The obtained value of 0.823 suggested a valid internal consistency, which implied the suitability of exploratory factor analysis. The exploratory factor analysis with unweighted least squares as the extraction method yielded seven factors with eigenvalues higher than 1, which indicated that more common variance than unique variance was explained by that factor (Lloret-Segura et al., 2014; Shrestha, 2021); these seven factors accounted for 63.75% of the explained variance in our model. Regarding reliability, we obtained a McDonald's omega of 0.905, which indicated that the questionnaire had a high internal reliability.

*Table 2. ASPT scale dimensions, components, and items*

| Dimension | Component | Items |
|---|---|---|
| DIM. 1. Attitudes towards probability | Affective (AP) | 1, 5, 16, 27 |
| | Cognitive competence (CP) | 6, 8, 17, 22 |
| | Behavioural (BP) | 2, 7, 15, 18 |
| DIM. 2. Attitudes towards the teaching of probability | Affective (AT) | 9, 21, 26, 28 |
| | Teaching competence (CT) | 3, 10, 14, 23 |
| | Behavioural (BT) | 11, 20, 24, 25 |
| DIM. 3. Value towards probability and its teaching | Value (VPT) | 4, 12, 13, 19 |

Questionnaire items were measured using a five-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). The results were qualitatively classified as follows for interpreting the results: negative attitudes ([1, 3)), neutral or indifferent attitudes (3), mild positive attitudes ((3, 3.8)), and positive attitudes ([3.8, 5]).

### 3.3. STATISTICAL ANALYSIS

Inferential analyses were carried out using SPSS Statistics 28.0 (IBM Corporation, 2021). First, the assumption of normality was analysed using the Kolmogorov-Smirnov ($n > 50$) or the Shapiro-Wilk ($n \leq 50$) test for the global ASPT, the dimensions, and the components among the corresponding categories or intervals of the complementary variables. Moreover, the mean, median, standard deviation, interquartile range, skewness, and kurtosis were calculated. Second, in order to analyse the attitudinal differences among the categories and intervals of the complementary variables, the nonparametric hypothesis tests—Mann-Whitney *U* for dichotomous variables (gender) and the Kruskal-Wallis *H* for variables with more than two categories (academic training) or intervals (work experience) —were used and evaluated using a significance level of .05. In addition, the effect sizes were estimated according to Tomczak and Tomczak (2014). For the dichotomous variable of gender, the Mann-Whitney *U*-test effect size, $r = Z/\sqrt{n}$ , was estimated, where *Z* is the standardised *Z*-score and *n* is the total number of observations on which *Z* is based. Subsequently, for the non-dichotomous variables of academic training and work experience, the Kruskal-Wallis effect size, $\eta^2 = (H - k + 1)/(n - k)$, was estimated, where *H* is the value obtained in the Kruskal-Wallis test, *k* represents the number of groups, and *n* is the total number of observations. These effect sizes indicated the effect that the grouping variable had on the continuous variable. Then, the Dunn-Bonferroni post-hoc test was used to make a pairwise comparison between the categories of the academic training variable and the intervals of the work experience variable to assess the differences between the two groups. To estimate the effect size, we again used *r*, which allowed us to quantify the magnitude of the differences between the two groups. The size effect of *r* is interpreted as a small ($r < 0.3$), medium ($0.3 \leq r \leq 0.5$), or large ($r > 0.5$) (J. Cohen, 1992) effect. Similarly, the $\eta^2$ size effect is interpreted as a small ($\eta^2 < 0.06$), medium ($0.06 \leq \eta^2 < 0.14$), or large ($\eta^2 \geq 0.14$) effect (B. H. Cohen, 2008).

### 3.4. ETHICS

This research was authorised by the Ethics Committee for Research and Teaching (CEID/IIEB) at the University of the Basque Country/Euskal Herriko Unibertsitatea (M10_2021_200).

## 4. RESULTS

In this section, a descriptive analysis of the ASPT questionnaire results is presented by reporting secondary mathematics teachers' overall attitudes towards probability and its teaching and their attitudes in relation to the three dimensions and seven components of Estrada and Batanero (2015) to respond to the first research question. Second, the inferential analysis is presented to answer the second research question about whether the attitudes of teachers towards probability and its teaching differ with regard to the complementary variables of gender, academic training, and work experience. The magnitude of this effect was also analysed. Moreover, some statistics of the study variables are presented to make the reader aware of the distribution of the data in each case and to show what considerations were used to perform the corresponding statistical analyses.

## 4.1. GLOBAL RESULTS

In this section, we present descriptive statistics corresponding to the ASPT scale and its respective dimensions and components (for additional descriptive analyses, see Anasagasti et al. (2024)) to understand the distribution of responses for each. In Table 3, we can see that all response distributions were left-skewed due to their negative values. For 50% or more of the teachers surveyed, the overall attitudes towards probability and its teaching (ASPT) were positive, as were the attitudes towards probability (DIM. 1), the attitudes towards probability teaching (DIM. 2), and the value towards probability and its teaching (DIM. 3). For each dimension and for the global ASPT, the value of the mean was less than the value of the median even though they were close in value. In terms of variability, responses for DIM. 3 (IQR = 1.00) had the greatest variability, whereas the global ASPT scale had the least variability (IQR = 0.73). For the first and second dimensions (DIM. 1 and DIM. 2), we observed that affective components had the greatest median scores and the greatest or tied for the greatest variability between the data (IQR = 1 and IQR = 1.25, respectively). In the first dimension (DIM. 1), the behavioural component had the lowest median score, with a mildly positive attitude manifesting a lower attitude towards probability. In the second dimension (DIM. 2), the median scores of the teaching and behavioural components coincide with a mildly positive attitude towards probability teaching competence and tendency to teach probability. Furthermore, the third dimension stood out positively with the greatest mean and median values among dimensions and components, indicating that teachers tended to value probability and its teaching.

*Table 3. Statistics for distributions of the ASPT scale, dimensions, and components*

| | Min. | Max. | Mean | Median | S.D. | IQR | Skewness | Kurtosis |
|---|---|---|---|---|---|---|---|---|
| Global ASPT | 2.57 | 4.86 | 3.91 | 4.04 | 0.54 | 0.73 | -0.37 | -0.63 |
| DIM. 1: Attitudes towards probability | 2.25 | 5.00 | 3.91 | 4.00 | 0.57 | 0.83 | -0.51 | -0.16 |
| Affective (AP) | 1.25 | 5.00 | 3.96 | 4.25 | 0.82 | 1.00 | -0.72 | 0.09 |
| Cognitive competence (CP) | 2.25 | 5.00 | 4.02 | 4.00 | 0.58 | 0.75 | -0.43 | -0.15 |
| Behavioural (BP) | 1.50 | 5.00 | 3.75 | 3.75 | 0.75 | 1.00 | -0.42 | -0.11 |
| DIM. 2: Attitudes towards the teaching of probability | 2.42 | 5.00 | 3.81 | 3.92 | 0.61 | 0.96 | -0.26 | -0.81 |
| Affective (AT) | 1.75 | 5.00 | 3.95 | 4.00 | 0.81 | 1.25 | -0.49 | -0.62 |
| Teaching competence (CT) | 2.00 | 5.00 | 3.80 | 3.75 | 0.73 | 1.25 | -0.25 | -0.63 |
| Behavioural (BT) | 2.00 | 5.00 | 3.70 | 3.75 | 0.70 | 1.00 | -0.22 | -0.61 |
| DIM. 3: Value towards probability and its teaching | 2.50 | 5.00 | 4.20 | 4.25 | 0.61 | 1.00 | -0.55 | -0.44 |

## 4.2. ANALYSIS FOR THE GENDER VARIABLE

In this section, we present the descriptive results of the ASPT survey according to gender and the inferential analysis regarding gender differences for the global ASPT scale, the three dimensions, and the respective components.

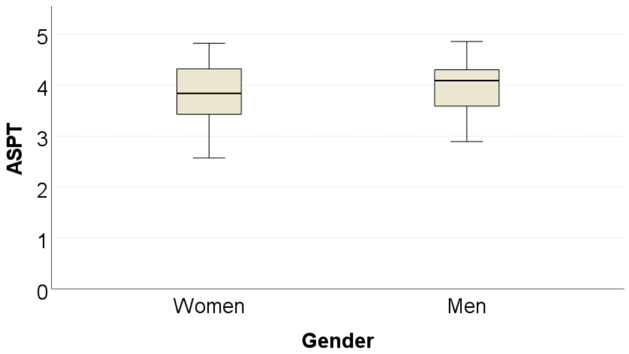


*Figure 1. Boxplots for the global ASPT with respect to gender*

The boxplots in Figure 1 show the distributions of the ASPT scale for women and men. Well over 50% of men have a positive attitude (31st percentile with a score above 3.8), whereas for women, 50% have a positive attitude (2nd quartile with a score above 3.8). Moreover, 7% of women had negative attitudes compared to only 3% of men. These results were complemented by the negative skew values displayed in Table 4; all of the distributions for gender were left-skewed. The median scores for men on the ASPT scale, dimensions, and components were greater than or equal to the median scores for women. With regard to the dimensions, the highest rated for both sexes was value towards probability and its teaching (DIM. 3), followed by the attitudes teachers had towards probability (DIM. 1) and attitudes towards teaching probability (DIM 2.). Focusing on the components, the worst rated among women was the behavioural component that assessed attitudes towards probability (DIM. 1). In contrast, among men, the teaching and behavioural components for attitudes towards teaching probability (DIM. 2) had the lowest median score. In addition, the interquartile ranges indicated, in general, greater variation among the scores from women.

*Table 4. Statistics and Kolmogorov-Smirnov (K-S) normality tests for global ASPT and ASPT dimensions and components for women (W) and men (M)*

| | | Mean | Median | SD | IQR | Skewness | Kurtosis | K-S (*p*-value) |
|---|---|---|---|---|---|---|---|---|
| Global ASPT | W | 3.86 | 3.84 | 0.57 | 0.90 | -0.251 | -0.778 | .260 |
| | M | 3.99 | 4.09 | 0.47 | 0.73 | -0.485 | -0.445 | .007 |
| DIM. 1: Attitudes towards probability | W | 3.84 | 3.88 | 0.60 | 0.85 | -0.354 | -0.281 | .007 |
| | M | 4.00 | 4.08 | 0.53 | 0.73 | -0.752 | 0.296 | .020 |
| Affective (AP) | W | 3.92 | 4.00 | 0.86 | 1.50 | -0.609 | -0.245 | <.001 |
| | M | 4.03 | 4.25 | 0.77 | 1.00 | -0.979 | 1.168 | <.001 |
| Cognitive competence (CP) | W | 3.99 | 4.00 | 0.61 | 1.00 | -0.609 | -0.245 | .009 |
| | M | 4.05 | 4.13 | 0.54 | 0.75 | -0.740 | 0.012 | <.001 |
| Behavioural (BP) | W | 3.62 | 3.50 | 0.77 | 1.25 | -0.172 | -0.485 | .016 |
| | M | 3.93 | 4.00 | 0.69 | 1.00 | -0.837 | 1.506 | .025 |
| DIM. 2: Attitudes towards the teaching of probability | W | 3.78 | 3.79 | 0.65 | 1.08 | -0.163 | 0.943 | .013 |
| | M | 3.87 | 3.90 | 0.57 | 0.79 | -0.443 | -0.546 | .048 |
| Affective (AT) | W | 3.87 | 4.00 | 0.85 | 1.50 | -0.293 | -0.882 | .005 |
| | M | 4.06 | 4.25 | 0.74 | 1.00 | -0.842 | 0.198 | <.001 |
| Teaching competence (CT) | W | 3.78 | 3.75 | 0.76 | 1.25 | -0.263 | -0.695 | .002 |
| | M | 3.81 | 3.75 | 0.70 | 1.19 | -0.197 | -0.626 | .003 |
| Behavioural (BT) | W | 3.70 | 3.75 | 0.69 | 1.00 | -0.207 | -0.616 | .005 |
| | M | 3.72 | 3.75 | 0.73 | 1.00 | -0.289 | -0.538 | .038 |
| DIM. 3: Value towards probability and its teaching | W | 4.13 | 4.25 | 0.64 | 1.00 | -0.405 | -0.609 | .002 |
| | M | 4.31 | 4.38 | 0.55 | 0.75 | -0.738 | -0.132 | <.001 |

According to the Kolmogorov-Smirnov normality test, the distributions of scores did not follow a normal distribution, with skewness and kurtosis values far from 0. Therefore, the nonparametric Mann-Whitney test was used in all cases to test for gender differences, and the corresponding effect size *r* was calculated for significant differences. The results displayed in Table 5 revealed no meaningful gender differences in the ASPT and corresponding dimension and component scores, with one exception. The exception is the behavioural component for attitudes towards probability (DIM. 1), which showed differences, although the effect size was small.

*Table 5. Mann-Whitney U test and effect size results for gender differences (W – M)*

| | *p*-value | | *r* |
|---|---|---|---|
| ASPT | .184 | | |
| DIM. 1: Attitudes towards probability | .056 | | |
| Affective (AP) | .448 | | |
| Cognitive competence (CP) | .326 | | |
| Behavioural (BP) | .004 | *W* - *M* | .016 |
| DIM. 2: Attitudes towards the teaching of probability | .429 | | |
| Affective (AT) | .141 | | |
| Teaching competence (CT) | .818 | | |
| Behavioural (BT) | .759 | | |
| DIM. 3: Value towards probability and its teaching | .071 | | |

## 4.3. ANALYSIS FOR THE ACADEMIC TRAINING VARIABLE

This section first presents the descriptive analysis of the global ASPT scale, its dimensions, and its components with respect to academic training. Second, inferential analyses are presented.

Figure 2 shows the distribution of scores obtained for the ASPT scale for each category of the academic training variable. The graphical displays were complemented by the information in Table B in Appendix B, which displays the mean, median, standard deviation, interquartile range, skewness, kurtosis, and Kolmogorov-Smirnov normality test results for the global ASPT scale as well as the three dimensions and the respective components for the academic training categories. The boxplots and results of the Kolmogorov-Smirnov and Shapiro-Wilk tests revealed that most of the distributions were asymmetric. People with training in mathematics showed the most positive overall attitudes, with a median score of 4.29, followed by people with training in physics (median = 4.07) and economics (median = 4.07). People with training in engineering (median = 3.89), experimental sciences (median = 3.64), and architecture (median = 3.50) showed lower overall median scores that were still above the neutral score of 3 on the scale. It is worth noting that a mathematician had the worst attitude score, although this score was an outlier. With regard to the interquartile range, those with economics (IQR = 1.11) and architecture (IQR = 1.32) training showed the largest variation among scores. Among the dimensions, as was the case for the gender variable, the highest median score in all categories was given to the attitude towards the value of probability (DIM. 3).

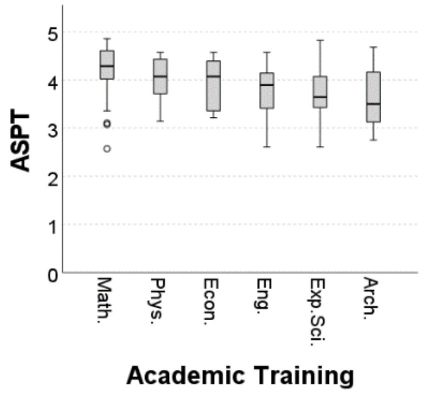


*Figure 2. Boxplots for the global ASPT for academic training*

The two most multitudinous groups, mathematics and engineering, presented left-skewed and platykurtic distributions for which there was no normality according to the distributions displayed in Figure 2 and the Kolmogorov-Smirnov normality test. For this reason, the nonparametric Kruskal-Wallis *H* test was used to examine possible differences between academic training groups.

Table 6 presents the results obtained by the Kruskal-Wallis *H* test together with the effect size, $\eta^2$, that represents differences in academic training for the ASPT scale, dimensions, and components. Except for the behavioural attitude towards probability component and the value towards probability and its teaching dimension that both showed no meaningful differences in academic training, differences in academic training revealed a medium–large size effect in differences. Moreover, the pairwise comparisons (see the last two columns in Table 6) both for the scale and for the dimensions, as well as for the components overall, revealed a medium-large size effect ($r \geq 0.3$) among the scores of people with training in mathematics and people with training in engineering, experimental sciences, and architecture. These results suggest that a background in mathematics is associated with relevant weight on a secondary mathematics teacher's attitude towards probability and probability teaching. Thus, the academic training of teachers is an important variable to consider in relation to teachers' attitudes towards probability and its teaching.

*Table 6. Academic training results for differences in scale, dimensions, and components and post-hoc comparisons between academic training categories*

| | Kruskal-Wallis | Effect size | Post-hoc comparisons for groups with significant differences | | |
|---|---|---|---|---|---|
| | *p*-value | $\eta^2$ | *p*-value | Groups | *r* |
| Global ASPT | <.001 | .153 | <.001 | Math - Eng | .41 |
| | | | <.001 | Math - ExpSci | .49 |
| | | | <.001 | Math - Arch | .40 |
| DIM. 1: Attitudes towards probability | <.001 | .118 | <.001 | Math - Eng | .32 |
| | | | <.001 | Math - ExpSci | .46 |
| | | | .005 | Math - Arch | .34 |
| | | | .045 | Phys - ExpSci | .28 |
| Affective (AP) | <.001 | .167 | <.001 | Math - Eng | .43 |
| | | | <.001 | Math - ExpSci | .47 |
| | | | <.001 | Math - Arch | .43 |
| | | | .040 | Econ - Arch | .50 |
| Cognitive competence (CP) | <.001 | .106 | .003 | Math - Eng | .28 |
| | | | <.001 | Math - ExpSci | .46 |
| | | | .006 | Math - Arch | .33 |
| Behavioural (BP) | .403 | | | | |
| DIM. 2 Attitudes towards the teaching of probability | <.001 | .171 | <.001 | Math - Eng | .45 |
| | | | <.001 | Math - ExpSci | .49 |
| | | | <.001 | Math - Arch | .42 |
| Affective (AT) | <.001 | .195 | <.001 | Math - Eng | .42 |
| | | | <.001 | Math - ExpSci | .58 |
| | | | <.001 | Math - Arch | .41 |
| Teaching competence (CT) | .001 | .082 | <.001 | Math - Eng | .34 |
| | | | <.001 | Math - ExpSci | .36 |
| | | | .028 | Math - Arch | .27 |
| | | | .028 | Math - Econ | .28 |
| Behavioural (BT) | <.001 | .098 | <.001 | Math - Eng | .36 |
| | | | .043 | Math - ExpSci | .21 |
| | | | <.001 | Math - Arch | .42 |
| | | | .041 | Phys - Arch | .45 |
| | | | .020 | Econ - Arch | .56 |
| | | | .036 | ExpSci - Arch | .29 |
| DIM. 3: Value towards probability and its teaching | .170 | | | | |

## 4.4. ANALYSIS FOR THE WORK EXPERIENCE VARIABLE

This section presents the descriptive results and the inferential analyses for the work experience variable with respect to the global ASPT scale, the three dimensions, and the respective components.

The boxplots in Figure 3 show the distribution of the ASPT scale for each interval, representing the number of years a teacher has taught. The boxplots are complemented with the statistics included in Table C in Appendix C and revealed that most of the distributions of ASPT scores for work experience were asymmetric. Teachers with more than 15 years of teaching had the highest attitudes with median scores of 4.11 (for (15, 20] years of teaching) and 4.14 (for (20, ∞) years of teaching), respectively, followed by novice teachers with less than 10 years of teaching who had median scores of 3.86 (for (0, 5] years of teaching) and 3.93 (for (5, 10] years of teaching), respectively. Teachers who taught between 10 and 15 years had the lowest attitude scores, with a median score of 3.52. Regarding the variation of the scores, teachers who taught for more than 20 years had the lowest variation in scores (IQR = 0.64), whereas the scores for all remaining teachers showed similarly larger variability.

With regard to dimension scores, we see again that for teachers at all levels of years of experience, the value given to probability (DIM. 3) is scored highest, followed by the attitudes teachers have towards probability (DIM. 1), and the attitudes towards teaching probability (DIM 2.), with the exception of teachers who taught between 10 and 15 years.

The distribution of global ASPT scores for teachers with more than 20 years of experience was not normally distributed, and skewness or kurtosis values were far from 0 for other categories of experience. For this reason, the nonparametric Kruskal-Wallis *H* test was used to examine possible differences between work experience groups.

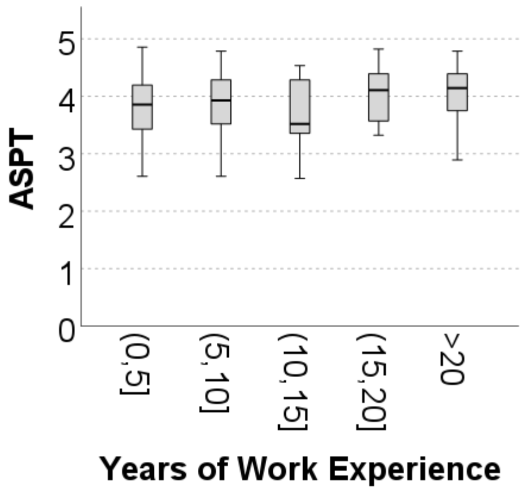


*Figure 3. Boxplots for the global ASPT scores for work experience intervals*

The second and third columns in Table 7 show the Kruskal-Wallis *H* test results and the $\eta^2$ size effects. The behavioural component towards teaching probability was the only component that showed a medium-sized effect for differences in work experience. The scores for the overall ASPT, dimensions, and remaining components showed small or no size effects for differences in work experience. On the other hand, the pairwise comparisons (see the last two columns in Table 7) showed a medium-sized effect, *r*, between the intervals of (10,15] years teaching and (15,20] years teaching for the ASPT scale, the attitude towards probability dimension, and the affective component towards probability. This means that there is a meaningful difference in scores between teachers with between 15 and 20 years of teaching experience and teachers with between 10 and 15 years of teaching experience for their attitude towards probability, especially with regard to personal feelings towards probability, as well as with regard to the global ASPT scale. Moreover, the attitude towards the teaching of probability dimension and the behavioural component towards teaching probability showed a medium-sized effect between teachers with less than five years of teaching and those with more than 20 years of teaching.

This suggests that teaching experience might yield meaningful differences in scores for attitudes towards probability teaching, especially with regard to the priority the teacher gives it over other topics. Thus, albeit to a lesser extent, work experience may be related to teachers' attitudes towards the didactic aspect of teaching probability.

*Table 7. Work experience results for differences in scale, dimensions, and components and post-hoc comparisons between work experience groups*

| | Kruskal-Wallis | Effect size | Post-hoc comparisons for groups with significant differences | | |
|---|---|---|---|---|---|
| | *p*-value | $\eta^2$ | *p*-value | Groups | *r* |
| Global ASPT | .026 | .039 | .045 | (15,20] - (10,15] | .33 |
| | | | .01 | (20, ∞) - (0,5] | .24 |
| | | | .015 | (20, ∞) - (10,15] | .27 |
| DIM. 1: Attitudes towards probability | .048 | .031 | .03 | (15,20] - (10,15] | .35 |
| | | | .005 | (20, ∞) - (10,15] | .31 |
| Affective (AP) | .006 | .057 | .013 | (15,20] - (10,15] | .40 |
| | | | .009 | (20, ∞) - (0,5] | .24 |
| | | | .002 | (20, ∞) - (10,15] | .34 |
| Cognitive competence (CP) | .651 | | | | |
| Behavioural (BP) | .184 | | | | |
| DIM. 2: Attitudes towards the teaching of probability | .006 | .058 | .022 | (15-20] - (0,5] | .27 |
| | | | <.001 | (20, ∞) - (0,5] | .30 |
| | | | .033 | (20, ∞) - (10,15] | .23 |
| Affective (AT) | .093 | | | | |
| Teaching competence (CT) | .141 | | | | |
| Behavioural (BT) | <.001 | .093 | .008 | (15,20] - (0,5] | .31 |
| | | | <.001 | (20, ∞) - (0,5] | .38 |
| | | | .013 | (20, ∞) - (5,10] | .26 |
| | | | .028 | (20, ∞) - (10,15] | .24 |
| DIM. 3: Value towards probability and its teaching | .655 | | | | |

## 5. DISCUSSION

The results provided a clear answer to the first research question: the attitude towards probability and its teaching (ASPT) of in-service secondary education teachers in the ACBC is positive overall, as evidenced by the global ASPT scale and its dimensions. In particular, the third dimension stood out most positively in suggesting the value given by teachers to probability and its teaching, aligning with results from other studies such as Estrada et al. (2016) and Ruz et al. (2023).

Furthermore, the inferential results allowed us to address the second question and determine attitude differences for complementary variables. Accordingly, we concluded that there was no meaningful difference between male and female teachers' attitudes towards probability and its teaching, adding to the research of Gil Flores (1999), Estrada et al. (2004), and Martins et al. (2015).

We concluded that academic training was an important variable to consider in relation to secondary mathematics teachers' attitudes. Teachers with training in mathematics had meaningfully higher scores in their attitudes towards probability and probability teaching when compared to teachers with a background in engineering, experimental sciences, or architecture. A possible justification for these differences can be found in the university curricula (both current and previous) of the aforementioned degrees. For example, the fact that engineering is found in this group may seem surprising. However, there are different types of engineering that, depending on the speciality, require more or fewer mathematics-related courses (Muñiz-Rodríguez et al., 2016), and little time is dedicated to the study of probability in any of them. According to what the authors have seen in the curricula of the universities of the ACBC, courses relating to statistics and probability are statistical methods in engineering and, in the case of computer scientists, also operations research. With regard to experimental sciences, we find either a biostatistics course or a mathematics and statistics course. Finally, in architecture, there are no courses directly related to statistics and probability. Moreover, the fact that teachers with academic training in these three degrees revealed lower attitude scores is consistent with the results obtained by Martins et al. (2015), who found better attitudes among teachers with specific training in their academic teaching area. Indeed, Becker et al. (2014) stated that the lack of knowledge about a subject can condition an individual's attitude and can lead to a situation where educational quality is not guaranteed. All this suggests that teachers' academic training might be a determining factor for attitudes, which may, in turn, affect the teaching and learning process.

Focusing on work experience, we observed a medium effect size in the behavioural component of the teaching probability dimension, i.e., in the didactic component. One possible reason could be that teachers with more experience feel more confident and competent in the subject matter to be taught, as years of teaching practice give them not only a greater mastery of the content but also greater pedagogical content knowledge (Copur-Gencturk & Li, 2023). This result contradicts the results obtained by Estrada et al. (2004), who concluded that attitudes worsen with years of experience. Given this diversity of results, work experience seems to be a variable that deserves to be studied in more depth.

Our results lead us to reaffirm the importance of disciplinary knowledge in both initial and continuing teacher training. In this sense, we join with the assertion of Muñiz-Rodríguez et al. (2016) on the need to establish global knowledge and skills that future mathematics teachers should acquire during their training period. Therefore, in the case of Spain, in order to reduce the heterogeneous mathematics teaching staff mentioned in the introduction, the authors believe that it would be advisable to standardise the minimum level of competence both to gain access to the master's degree and to become a mathematics teacher.

## 6. CONCLUSIONS

Probability is becoming increasingly more useful in today's society, yet it is not given sufficient attention in schools. In this study, we wanted to investigate whether teachers' gender, academic training, and years of work experience are variables that reveal differences in teachers' attitudes. Although, in part, we wanted our results to contribute to a change in the current situation of the ACBC system, we believe that these results can be useful beyond the ACBC because they suggest important variables in socio-educational contexts that should be considered with respect to secondary mathematics teachers' attitudes towards probability more broadly.

One conclusion of the research that is perhaps striking is that the gender variable revealed no meaningful difference in attitudes towards probability and its teaching despite the widening gender gap identified by Petroff et al. (2021). This may be due to the small sample size of this study, the voluntary nature of the questionnaire, or the anonymity afforded to participants. We can conclude that different intervals of work experience showed meaningful differences in teachers' attitudes towards the teaching of probability. Teachers with more work experience had better attitudes towards the didactic aspect of teaching probability than novice teachers. We also can conclude that secondary mathematics teachers with a background in mathematics had meaningfully higher attitude scores than teachers with training in engineering, experimental sciences, or architecture. These results point to the importance of both initial and continuing probability training of secondary school mathematics teachers.

As for the limitations of the study, it should be pointed out that although the questionnaire was sent to all secondary school management teams in the ACBC for distribution to mathematics teachers, only 16.4% of teachers responded. This work, therefore, invites the uptake of a larger-scale study. Furthermore, future research work would benefit from qualitative inquiry to assess the reasons why part of the teaching staff showed negative attitudes towards probability and its teaching.

## ACKNOWLEDGEMENTS

This article was partially supported by the UPV/EHU Research Group GIU21/031.

**REFERENCES**

Alvarado, H., Andaur, G., & Estrada, A. (2018). Actitudes hacia la probabilidad y su enseñanza: Un estudio exploratorio con profesores de matemáticas en formación y en ejercicio de Chile [Attitudes towards probability and its teaching: An exploratory study with pre-service and in-service mathematics teachers from Chile]. *Revista Paradigma*, *39*(2), 36–64. https://revistaparadigma.com.br/index.php/paradigma/article/view/700/696

Anasagasti, J., Berciano, A., & Izagirre, A. (2023). Actitudes hacia la probabilidad del profesorado de matemáticas de educación secundaria Chile [Attitudes towards probability of secondary school mathematics teachers in Chile]. In C. Jiménez-Gestal, Á. A. Magreñán, E. Badillo, & P. Ivars (Eds.), *Investigación en educación matemática XXVI* (pp. 123–130). Simposio de la Sociedad Española de Investigación en Educación Matemática.

Anasagasti, J., Izagirre, A., & Berciano, A. (2024). Actitudes hacia la probabilidad y su enseñanza del profesorado de educación secundaria [Attitudes towards probability and its teaching among secondary school teachers]. *Educación Matemática*, *36*(3), 143–172. https://doi.org/10.24844/EM3603.06

Auzmendi, E. (1992). *Las actitudes hacia la matemática–estadística en las enseñanzas medias y universitarias* [Attitudes towards mathematics–statistics in secondary and university education]. Mensajero.

Basque Government Department of Education. (2012, September 11). *Boletín oficial del País Vasco* [Official bulletin of the Basque country] (Orden núm. 177). https://www.euskadi.eus/bopv2/datos/2012/09/1204082a.pdf

Basque Government Department of Education. (2020, February 27). *Boletín oficial del País Vasco* [Official bulletin of the Basque country] (Orden núm. 40). https://www.euskadi.eus/bopv2/datos/2020/02/2001164a.pdf

Basque Government Department of Education (2021, October 29). *Estadísticas del sistema educativo* [Statistics of the education system]. Retrieved January 26, 2025, from https://www.euskadi.eus/matricula-2021-2022-tablas/web01-a2hestat/es/

Batanero, C., & Álvarez-Arroyo, R. (2024). Teaching and learning of probability. *ZDM Mathematics Education, 56*(1), 5–17. https://doi.org/10.1007/s11858-023-01511-5

Batanero, C., Chernoff, E. J., Engel, J., Lee, H. S., & Sánchez, E. (2016). Research on teaching and learning probability. In C. Batanero, E. J. Chernoff, J. Engel, H.S. Lee, & E. Sánchez (Eds.), Research on teaching and learning probability (pp. 1-33). Springer. https://doi.org/10.1007/978-3-319-31625-3_1

Becker, E. S., Goetz, T., Morger, V., & Ranellucci, J. (2014). The importance of teachers' emotions and instructional behavior for their students' emotions––An experience sampling analysis. *Teaching and Teacher Education*, *43*, 15–26. http://doi.org/10.1016/j.tate.2014.05.002

Beltrán-Pellicer, P., Godino, J. D., & Giacomone, B. (2018). Elaboración de indicadores específicos de idoneidad didáctica en probabilidad: Aplicación para la reflexión sobre la práctica docente [Elaboration of specific didactical suitability criteria in probability: Application for reflection on the teaching practice]. *Bolema, 32*(61), 526–548. https://doi.org/10.1590/1980-4415v32n61a11

Carmona, J. (2004). Una revisión de las evidencias de fiabilidad y validez de los cuestionarios de actitudes y ansiedad hacia la estadística [A review of the evidence for the reliability and validity of questionnaires on attitudes and anxiety towards statistics]. *Statistics Education Research Journal, 3*(1), 5–28. https://doi.org/10.52041/serj.v3i1.539

Carraza, I., Llano, E., Lueje, J. L., Martín, T., Mogollón, L., Moreno, M. P., Moreno, M. A., Ruiz, M. I., & Valdeón, E. (2008). *Breve diccionario coeducativo* [A brief coeducational dictionary]. Consejería de Educación y Ciencia.

Carrillo, J., Climent, N., Montes, M., Contreras, L. C., Flores-Medrano, E., Escudero-Ávila, D. V, Rojas, N., Flores, P., Aguilar-González, Á., Ribeiro, M., & Muñoz-Catalán, M. C. (2018). The mathematics teacher's specialised knowledge (MTSK) model. *Research in Mathematics Education, 20*(3), 236–253. https://doi.org/10.1080/14794802.2018.1479981

Cohen, J. (1992). A power primer. *Psychological Bulletin*, *112*(1), 155–159. https://doi.org/10.1037/0033-2909.112.1.155

Cohen, B. H. (2008). *Explaining psychological statistics* (3rd ed.). John Wiley & Sons.

Copur-Gencturk, Y., & Li, J. (2023). Teaching matters: A longitudinal study of mathematics teachers' knowledge growth. *Teaching and Teacher Education, 121*, Article 103949. https://doi.org/10.1016/j.tate.2022.103949

Dede, Y. (2013). The effect of German and Turkish mathematics teachers' teaching experience on mathematics education values: A cross-comparative study. *International Journal of Mathematical Education in Science and Technology, 44*(2), 232–252. https://doi.org/10.1080/0020739X.2012.714489

Estrada, A. (2002). *Análisis de las actitudes y conocimientos estadísticos elementales en la formación del profesorado* [Analysis of basic statistical skills and attitudes in teacher training] [Unpublished doctoral dissertation]. Universitat Autònoma de Barcelona.

Estrada, A., & Batanero, C. (2015). Construcción de una escala de actitudes hacia la probabilidad y su enseñanza para profesores [Construction of a scale of attitudes towards probability and its teaching for teachers]. In C. Fernández, M. Molina, & N. Planas (Eds.), *Investigación en Educación Matemática XIX* (pp. 239–247). Simposio de la Sociedad Española de Investigación en Educación Matemática.

Estrada, A., & Batanero, C. (2020). Prospective primary school teachers' attitudes towards probability and its teaching. *International Electronic Journal of Mathematics Education, 15*(1), Article em0559. https://doi.org/10.29333/iejme/5941

Estrada. A., Batanero, C., Comas, C., & Díaz, C. (2016, July 24–31). *Exploring teachers' attitudes towards probability and its teaching* [Paper presentation]. 13th International Congress on Mathematical Education, Hamburg, Germany. https://iase-web.org/documents/papers/icme13/ICME13_L2_Estrada.pdf

Estrada, A., Batanero, C., & Fortuny, J. M. (2004). Un estudio comparado de las actitudes hacia la estadística en profesores en formación y en ejercicio [A comparative study of attitudes towards statistics in pre-service and in-service teachers]. *Enseñanza de las Ciencias, 22*(2), 263–274. https://doi.org/10.5565/rev/ensciencias.3888

Gil Flores, J. (1999). Actitudes hacia la estadística. Incidencia de las variables sexo y formación previa. [Attitudes towards statistics. Incidence of the variables sex and previous education]. *Revista Española de Pedagogía, 214*, 567–590. https://doi.org/10.22550/2174-0909.2196

Godino, J. D. (2010). *Perspectiva de la didáctica de las matemáticas como disciplina tecnocientífica* [Perspective of mathematics didactics as a technoscientific discipline]. Universidad de Granada.

Guiñez, F., Vásquez, C., Brito, C., & Martínez, S. (2021). Alice in randomland: A resource for improving attitudes towards probability and its teaching. *Statistics Education Research Journal, 20*(2), Article 14. https://doi.org/10.52041/serj.v20i2.410

Hernández, R., Fernández, C., & Baptista, P. (2014). *Metodología de la investigación* (6ª ed.). [Research methodology (6th ed.)]. McGraw-Hill.

Hill, H. C., Rowan, B., & Ball, D. L. (2005). Effects of teachers' mathematical knowledge for teaching on student achievement. *American Educational Research Journal, 42*(2), 371–406. http://doi.org/10.3102/00028312042002371

Huber, S., Reinhold, F., Obersteiner, A., & Reiss, K. (2024). Teaching statistics with positive orientations but limited knowledge? Teachers' professional competence in statistics. *Statistics Education Research Journal, 23(1),* Article 2. https://doi.org/10.52041/serj.v23i1.610

IBM Corporation. (2021). *IBM SPSS Statistics for Windows* (Version 28.0) [Computer Software].

Jacobs G. J., & Spangenberg, E. D. (2014). Mathematics teachers' attitudes towards the subject: The influence of gender, age, and teaching experience. In D. Mogari, U. Ogbonnaya, & K. Padayachee (Eds.), *ISTE International Conference on Mathematics, Science, and Technology Education* (pp. 91–100). Unisa Press.

Lloret-Segura, S., Ferreres-Traver, A., Hernández-Baeza, A., & Tomás-Marco, I. (2014). El análisis factorial exploratorio de los ítems: Una guía práctica revisada y actualizada [Exploratory item factor analysis: A practical guide revised and updated]. *Anales de psicología, 30*(3), 1151–1169. https://doi.org/10.6018/analesps.30.3.199361

Marbán, J. M. (2016). Matemáticas y dominio afectivo [Mathematics and affective domain]. In J. A. Macías, A. Jiménez, J. L. González, M. T. Sánchez, P. Hernández, C. Fernández, F. J. Ruiz, T. Fernández, & A. Berciano (Eds.), *Investigación en educación matemática XX* (pp. 69–74). Simposio de la Sociedad Española de Investigación en Educación Matemática.

Martins, J. A., Estrada, A., Nascimento, M. M., & Comas, C. (2015). Actitudes hacia la estadística de los profesores: Un camino a recorrer [Teachers' attitudes towards statistics: A way forward]. In J. M. Contreras, C. Batanero, J. D. Godino, G. R. Cañadas, P. Arteaga, E. Molina, M. M. Gea, & M. M. López (Eds.), *Didáctica de la estadística, probabilidad, y combinatoria* (Vol. 2, pp. 101–107). Universidad de Granada.

McLeod, D. B. (1992). Research on affect in mathematics education: A reconceptualization. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning: A project of the National Council of Teachers of Mathematics* (pp. 575–596). Macmillan.

McLeod, D. B., & McLeod, S. H. (2002). Synthesis—Beliefs and mathematics education: Implication for learning, teaching, and research. In G. C. Leder, E. Pehkonen, & G. Törner (Eds.), *Beliefs: A hidden variable in mathematics education?* (pp. 177–193). Kluwer Academic Publishers. https://doi.org/10.1007/0-306-47958-3_7

Muñiz-Rodríguez, L., Alonso Velázquez, P., Rodríguez-Muñiz, L. J., & Valcke, M. (2016). ¿Hay un vacío en la formación inicial del profesorado de matemáticas de Secundaria en España respecto a otros países? [Is there a gap in the initial training of secondary mathematics teachers in Spain compared to other countries?]. *Revista de Educación, 372*(5), 111‑140. https://doi.org/10.4438/1988-592X-RE-2015-372-317

Petroff, A., Sáinz, M., & Arroyo, L. (2021). A multilevel qualitative perspective to gendered life course, socialization, and STEM trajectories among emerging adults in Spain. *Emerging Adulthood*, 10(5), 1256–1268. https://doi.org/10.1177/21676968211021678

Roberts, D. M., & Bilderback, E. W. (1980). Reliability and validity of a statistics attitudes survey. *Educational and Psychological Measurement, 40*(1), 235–238. https://doi.org/10.1177/001316448004000138

Ruz, F., Berciano, A., Martínez-Ortiz, F., & Contreras García, J. M. (2023). Perspectiva de género en actitudes hacia la probabilidad y su enseñanza en futuro profesorado chileno [Gender perspective on attitudes towards probability and its teaching among future Chilean teachers]. *Revista Educação e Pesquisa, 49*, Article e254527. https://doi.org/10.1590/S1678-4634202349254527es

Schau, C., Stevens, J., Dauphine, T., & Del Vecchio, A. (1995). The development of the survey of attitudes towards statistics. *Educational and Psychological Measurement, 55*(5), 868–875. https://doi.org/10.1177/0013164495055005022

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4–14. https://doi.org/10.3102/0013189X015002004

Shrestha, N. (2021). Factor analysis as a tool for survey analysis. *American Journal of Applied Mathematics and Statistics, 9*(1), 4–11. https://doi.org/10.12691/ajams-9-1-2

Tomczak, M., & Tomczak, E. (2014). The need to report effect size estimates revisited. An overview of some recommended measures of effect size. *Trends in Sport Sciences, 1*(21), 19–25.

Topchyan, R., & Woehler, C. (2021). Do teacher status, gender, and years of teaching experience impact job satisfaction and work engagement? *Education and Urban Society, 53*(2), 119–145. https://doi.org/10.1177/0013124520926161

Wise, S. L. (1985). The development and validation of a scale measuring attitudes towards statistics. *Educational and Psychological Measurement, 45*(2), 401–405. https://doi.org/10.1177/001316448504500226

Wyer, R. S., & Albarracín, D. (2014). Belief formation, organisation, and change: Cognitive and motivational influences. In D. Albarracín, T. Johnson, & M. P. Zanna (Eds.), *The handbook of attitudes* (pp. 273–322). Psychology Press.

ANE IZAGIRRE
University of the Basque Country (UPV/EHU)
Faculty of Education, Philosophy and Anthropology
Department of Didactics of Mathematics, Experimental and Social Sciences
Oñati Plaza 3
20018 Donostia

## APPENDIX A: ATTITUDES' SCALE TOWARDS PROBABILITY AND ITS TEACHING

*Table A. Estrada and Batanero's (2015) Attitudes' Scale towards Probability and its Teaching (ASPT) adapted to include more inclusive language and to address in-service teachers*

| Number | Item |
|---|---|
| 1 | I enjoy the lessons where probability is explained. |
| 2 | I use probability information when making decisions. |
| 3* | It is difficult for me to teach probability. |
| 4 | Probability helps me understand today's world. |
| 5 | I like probability; it is a subject that has always interested me. |
| 6 | Probability is easy. |
| 7* | I have never used probability outside mathematics. |
| 8 | I have mastered the main contents of probability. |
| 9 | I think I enjoy teaching probability in school. |
| 10 | I think I can notice and correct students' errors and difficulties with probability. |
| 11* | I only teach probability if I have time left after teaching the other topics. |
| 12* | Probability is only useful for games of chance. |
| 13* | Probability is not as valuable as other areas of mathematics. |
| 14 | I find it easy to design probability assessment tasks. |
| 15 | I use probability in everyday life. |
| 16* | I feel scared when faced with probability information. |
| 17* | Probability is understandable only to "science people". |
| 18* | I avoid reading information that contains probability terms (e.g. in drugs prospects.). |
| 19 | Probability knowledge helps students to reason critically. |
| 20 | Probability should be taught from the earliest teaching levels. |
| 21* | I feel worried about being able to answer students' probability questions. |
| 22* | I do not feel well enough prepared to solve any basic probability problem. |
| 23* | I feel that I am not able to prepare suitable didactic resources for the probability lesson. |
| 24 | When relevant, I use probability in other subjects that I teach. |
| 25* | If I could skip a topic, it would be probability. |
| 26* | I am not very interested in teaching probability even though it appears in the curriculum. |
| 27* | I do not enjoy solving probability problems. |
| 28 | As a teacher, I think I feel comfortable teaching probability. |

* Items with a negative character were reversed before statistical calculation.

## APPENDIX B: ACADEMIC TRAINING

*Table B. Statistics and Kolmogorov-Smirnov (K-S) or Shapiro-Wilk (S-W) normality tests for global ASPT and ASPT dimensions and components for the academic training variable*

| | Academic Training | Mean | Median | SD | IQR | Skewness | Kurtosis | K-S/S-W (*p*-value) |
|---|---|---|---|---|---|---|---|---|
| Global ASPT | Math | 4.22 | 4.29 | 0.49 | 0.60 | -1.19 | 1.41 | .013 |
| | Phys | 4.01 | 4.07 | 0.50 | 0.83 | -0.53 | -0.87 | .409 |
| | Econ | 3.95 | 4.07 | 0.56 | 1.11 | -0.40 | -1.90 | .439 |
| | Eng | 3.80 | 3.89 | 0.48 | 0.75 | -0.39 | -0.78 | .002 |
| | ExpSci | 3.71 | 3.64 | 0.47 | 0.66 | -0.10 | 0.16 | .862 |
| | Arch | 3.60 | 3.50 | 0.65 | 1.32 | 0.23 | -1.13 | .429 |
| DIM. 1: Attitudes towards probability | Math | 4.19 | 4.25 | 0.51 | 0.56 | -1.04 | 1.31 | .016 |
| | Phys | 4.07 | 4.08 | 0.48 | 0.92 | -0.31 | -1.29 | .181 |
| | Econ | 3.97 | 4.21 | 0.74 | 1.32 | -0.72 | -0.63 | .540 |
| | Eng | 3.83 | 3.92 | 0.54 | 0.92 | -0.59 | 0.03 | .025 |
| | ExpSci | 3.68 | 3.67 | 0.52 | 0.66 | -0.59 | 0.60 | .189 |
| | Arch | 3.65 | 3.50 | 0.70 | 1.08 | 0.37 | -0.74 | .624 |
| Affective (AP) | Math | 4.40 | 4.75 | 0.70 | 1.00 | -1.15 | 0.28 | <.001 |
| | Phys | 4.20 | 4.38 | 0.52 | 1.00 | -0.39 | -0.99 | .048 |
| | Econ | 4.38 | 4.25 | 0.52 | 1.10 | 0.40 | -1.62 | .248 |
| | Eng | 3.75 | 4.00 | 0.82 | 1.25 | -0.61 | -0.11 | .001 |
| | ExpSci | 3.66 | 3.75 | 0.81 | 0.88 | -1.03 | 1.31 | .008 |
| | Arch | 3.50 | 3.25 | 0.79 | 1.25 | 0.54 | -1.15 | .190 |
| Cognitive competence (CP) | Math | 4.29 | 4.38 | 0.50 | 0.69 | -0.62 | 0.15 | .001 |
| | Phys | 4.10 | 4.25 | 0.60 | 0.94 | -0.83 | -0.37 | .236 |
| | Econ | 4.00 | 4.00 | 0.61 | 1.00 | 0.61 | 0.63 | .753 |
| | Eng | 3.98 | 4.00 | 0.52 | 0.75 | -0.78 | 0.97 | .005 |
| | ExpSci | 3.77 | 3.75 | 0.54 | 0.75 | -0.24 | -0.52 | .133 |
| | Arch | 3.77 | 3.75 | 0.77 | 0.50 | 0.15 | 0.14 | .284 |
| Behavioural (BP) | Math | 3.87 | 4.00 | 0.79 | 1.00 | -0.74 | 0.55 | .024 |
| | Phys | 3.90 | 4.00 | 0.64 | 1.06 | -0.45 | -0.66 | .704 |
| | Econ | 3.54 | 4.25 | 1.24 | 2.06 | -1.21 | -0.27 | .027 |
| | Eng | 3.76 | 3.75 | 0.71 | 1.00 | -0.30 | -0.21 | .200 |
| | ExpSci | 3.59 | 3.50 | 0.71 | 1.25 | ~0.00 | -0.65 | .472 |
| | Arch | 3.66 | 3.25 | 0.78 | 1.25 | 0.60 | -1.17 | .126 |
| DIM. 2 Attitudes towards the teaching of probability | Math | 4.18 | 4.33 | 0.59 | 0.73 | -1.12 | 0.83 | .002 |
| | Phys | 3.93 | 3.92 | 0.58 | 0.98 | -0.24 | -0.69 | .882 |
| | Econ | 3.88 | 3.92 | 0.45 | 0.73 | -0.65 | -0.80 | .351 |
| | Eng | 3.65 | 3.75 | 0.55 | 1.00 | -0.24 | -1.00 | .177 |
| | ExpSci | 3.62 | 3.58 | 0.51 | 0.88 | 0.28 | -0.40 | .417 |
| | Arch | 3.45 | 3.50 | 0.72 | 1.25 | -0.16 | -1.59 | .345 |
| Affective (AT) | Math | 4.44 | 4.75 | 0.66 | 1.00 | -1.27 | 0.93 | <.001 |
| | Phys | 4.08 | 4.13 | 0.69 | 1.31 | -0.23 | -1.31 | .670 |
| | Econ | 4.08 | 4.13 | 0.54 | 0.94 | -0.46 | -0.30 | .964 |
| | Eng | 3.80 | 4.00 | 0.76 | 1.25 | -0.64 | -0.49 | <.001 |
| | ExpSci | 3.54 | 3.50 | 0.73 | 1.00 | -0.09 | 0.09 | .641 |
| | Arch | 3.55 | 3.25 | 0.94 | 1.50 | 0.38 | -0.95 | .531 |
| Teaching competence (CT) | Math | 4.13 | 4.25 | 0.72 | 1.00 | -0.81 | 0.33 | .007 |
| | Phys | 3.88 | 3.88 | 0.64 | 1.06 | -0.30 | -0.76 | .804 |
| | Econ | 3.50 | 3.63 | 0.55 | 0.94 | -0.17 | -0.78 | .783 |
| | Eng | 3.67 | 3.75 | 0.67 | 1.00 | -0.02 | -0.44 | .015 |
| | ExpSci | 3.62 | 3.75 | 0.70 | 1.25 | -0.33 | -0.88 | .034 |
| | Arch | 3.59 | 3.50 | 0.93 | 1.75 | -0.04 | -0.75 | .894 |
| Behavioural (BT) | Math | 3.98 | 4.00 | 0.69 | 0.75 | -0.63 | -0.08 | .009 |
| | Phys | 3.83 | 3.88 | 0.47 | 0.81 | -0.42 | -0.57 | .835 |
| | Econ | 4.04 | 4.13 | 0.73 | 1.38 | -0.39 | -1.81 | .310 |
| | Eng | 3.48 | 3.50 | 0.68 | 1.00 | -0.04 | -0.58 | .200 |
| | ExpSci | 3.70 | 3.75 | 0.67 | 1.00 | -0.24 | -0.44 | .480 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Arch | 3.20 | 3.25 | 0.55 | 1.00 | -0.35 | -0.64 | .792 |
| DIM. 3: Value towards probability and its teaching | Math | 4.39 | 4.50 | 0.51 | 0.75 | -0.47 | -0.77 | <.001 |
| | Phys | 4.13 | 4.25 | 0.65 | 1.06 | -1.08 | 0.89 | .169 |
| | Econ | 4.08 | 4.13 | 0.68 | 1.06 | -0.44 | 0.59 | .985 |
| | Eng | 4.17 | 4.25 | 0.62 | 1.00 | -0.56 | -0.32 | .017 |
| | ExpSci | 4.10 | 4.25 | 0.62 | 0.88 | -0.31 | -0.74 | .062 |
| | Arch | 3.91 | 3.75 | 0.79 | 1.75 | -0.10 | -1.50 | .383 |

## APPENDIX C: WORK EXPERIENCE

*Table C. Statistics and Kolmogorov-Smirnov (K-S) or Shapiro-Wilk (S-W) normality tests for global ASPT and ASPT dimensions and components for the work experience variable*

| | Work Experience | Mean | Median | SD | IQR | Skewness | Kurtosis | K-S/S-W (*p*-value) |
|---|---|---|---|---|---|---|---|---|
| ASPT | (0,5] | 3.78 | 3.86 | 0.55 | 0.81 | -0.30 | -0.64 | .087 |
| | (5,10] | 3.88 | 3.93 | 0.53 | 0.82 | -0.41 | -0.20 | .866 |
| | (10,15] | 3.70 | 3.52 | 0.57 | 0.95 | 0.06 | -0.84 | .122 |
| | (15,20] | 4.07 | 4.11 | 0.49 | 0.88 | 0.01 | -1.35 | .283 |
| | (20, ∞) | 4.05 | 4.14 | 0.49 | 0.64 | -0.56 | -0.56 | .015 |
| DIM. 1: Attitudes towards probability | (0,5] | 3.84 | 3.88 | 0.57 | 0.90 | -0.45 | -0.09 | .095 |
| | (5,10] | 3.88 | 4.00 | 0.57 | 0.92 | -0.98 | 1.30 | .106 |
| | (10,15] | 3.60 | 3.46 | 0.64 | 1.02 | 0.21 | -0.57 | .603 |
| | (15,20] | 4.03 | 4.13 | 0.50 | 0.83 | -0.38 | -0.96 | .277 |
| | (20, ∞) | 4.04 | 4.13 | 0.54 | 0.73 | -0.60 | 0.06 | .012 |
| Affective (AP) | (0,5] | 3.82 | 4.00 | 0.79 | 1.25 | -0.24 | -0.91 | .081 |
| | (5,10] | 3.88 | 4.00 | 0.82 | 1.00 | -1.20 | 1.67 | .010 |
| | (10,15] | 3.51 | 3.50 | 0.91 | 1.44 | -0.19 | -0.10 | .815 |
| | (15,20] | 4.19 | 4.50 | 0.74 | 1.10 | -0.86 | -0.35 | .010 |
| | (20, ∞) | 4.18 | 4.25 | 0.78 | 1.38 | -1.20 | 1.86 | <.001 |
| Cognitive competence (CP) | (0,5] | 4.01 | 4.00 | 0.62 | 0.75 | -0.69 | 0.40 | .036 |
| | (5,10] | 4.01 | 4.00 | 0.60 | 1.00 | -3.10 | -0.88 | .199 |
| | (10,15] | 3.86 | 3.88 | 0.56 | 0.69 | 0.06 | -0.66 | .157 |
| | (15,20] | 4.00 | 4.00 | 0.51 | 0.81 | 0.10 | -0.18 | .839 |
| | (20, ∞) | 4.07 | 4.00 | 0.56 | 0.75 | -0.49 | ~0.00 | .005 |
| Behavioural (BP) | (0,5] | 3.69 | 3.75 | 0.72 | 1.00 | -0.07 | -0.50 | .037 |
| | (5,10] | 3.74 | 4.00 | 0.75 | 1.25 | -0.38 | -0.72 | .198 |
| | (10,15] | 3.43 | 3.25 | 0.94 | 1.19 | -0.19 | 0.04 | .261 |
| | (15,20] | 3.90 | 4.00 | 0.55 | 0.81 | 0.04 | -0.45 | .722 |
| | (20, ∞) | 3.87 | 4.00 | 0.74 | 1.00 | -0.66 | 0.25 | .004 |
| DIM. 2: Attitudes towards the teaching of probability | (0,5] | 3.62 | 3.75 | 0.61 | 0.98 | -0.24 | -0.78 | .052 |
| | (5,10] | 3.75 | 3.75 | 0.61 | 1.08 | 0.12 | -1.30 | .083 |
| | (10,15] | 3.65 | 3.63 | 0.66 | 1.10 | -0.04 | -0.82 | .520 |
| | (15,20] | 4.03 | 4.13 | 0.56 | 0.88 | 0.01 | -0.87 | .704 |
| | (20, ∞) | 4.00 | 4.17 | 0.57 | 0.75 | -0.54 | -0.68 | .006 |
| Affective (AT) | (0,5] | 3.78 | 4.00 | 0.79 | 1.38 | -0.24 | -1.08 | .002 |
| | (5,10] | 3.89 | 4.00 | 0.82 | 1.25 | -0.62 | -0.23 | .172 |
| | (10,15] | 3.79 | 3.75 | 0.83 | 1.44 | -0.27 | -0.63 | .423 |
| | (15,20] | 4.11 | 4.13 | 0.64 | 1.25 | -0.12 | -1.09 | .303 |
| | (20, ∞) | 4.12 | 4.25 | 0.83 | 1.19 | -0.83 | ~0.00 | .002 |
| Teaching competence (CT) | (0,5] | 3.65 | 3.75 | 0.78 | 1.25 | 0.02 | -0.81 | .200 |
| | (5,10] | 3.79 | 3.75 | 0.71 | 1.25 | -0.01 | -0.55 | .542 |
| | (10,15] | 3.61 | 3.63 | 0.78 | 1.38 | -0.22 | -0.21 | .496 |
| | (15,20] | 4.04 | 4.00 | 0.53 | 0.81 | 0.05 | -0.53 | .751 |
| | (20, ∞) | 3.91 | 4.00 | 0.71 | 1.00 | -0.46 | -0.52 | .021 |
| Behavioural (BT) | (0,5] | 3.45 | 3.50 | 0.66 | 0.75 | 0.18 | -0.11 | .098 |
| | (5,10] | 3.56 | 3.50 | 0.68 | 0.75 | -0.17 | -0.17 | .740 |
| | (10,15] | 3.54 | 3.63 | 0.76 | 1.19 | -0.41 | -0.84 | .087 |
| | (15,20] | 3.94 | 4.13 | 0.77 | 1.19 | -0.39 | -0.91 | .353 |
| | (20, ∞) | 3.96 | 4.00 | 0.60 | 0.94 | -0.45 | -0.49 | .004 |
| DIM. 3: Value towards probability and its teaching | (0,5] | 4.09 | 4.25 | 0.67 | 1.19 | -0.35 | -0.97 | .022 |
| | (5,10] | 4.28 | 4.50 | 0.63 | 1.00 | -1.07 | 1.06 | .010 |
| | (10,15] | 4.15 | 4.13 | 0.71 | 1.19 | -0.33 | -1.10 | .037 |
| | (15,20] | 4.28 | 4.25 | 0.48 | 0.81 | -0.12 | -1.00 | .378 |
| | (20, ∞) | 4.27 | 4.25 | 0.55 | 0.75 | -0.55 | -0.13 | .010 |