EXPLORING TEACHERS' ATTITUDES TOWARDS PROBABILITY AND ITS TEACHING

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In this paper we describe the first steps in building a scale directed to measure the attitudes towards probability and its teaching of primary school teachers. The components considered in building the instrument and the process of selecting the items, as well as a first version of the instrument will be presented. Validity and reliability of the instrument will be discussed, and preliminary results in pilot samples will be available for the conference.

INTRODUCTION

Probability is a new topic at the primary school level in many countries and specifically in Spain (MECD, 2014), where the topic is included since the first grade (6 year-olds students). We also attend to a change in the teaching approach towards the frequentist view, based on simulation and experiments with the aim of providing children with a stochastic experience from their childhood (Batanero, 2013).

The success of this curricular proposal directly depends on teachers' willingness and interest to teach the topic. In addition to improving the cognitive side of instruction, further attention should also be paid to non-cognitive factors such as students' attitudes and motivations (Gal, & Ginsburg (1994). Due to the novelty of this topic, many prospective and in service primary school teachers have not received a specific education in probability or probability education and may feel uncomfortable when confronted with its teaching. Therefore these teachers may consider themselves not well prepared or may not value the formative role of probability for their students (Batanero & Díaz, 2012). Consequently, the assessment of these teachers' attitudes towards probability and its teaching, using valid and reliable instruments is a preliminary step to organize formative actions that take into account not only the teachers' knowledge, but the components in their attitudes.

Even when today there are various instruments to measure attitudes towards statistics, there is no available scale to measure the attitudes towards probability; moreover the few scales of attitudes towards statistics directed specifically to teachers do not consider the components of attitudes related to the teaching. To fulfil this need we started developing a valid and reliable questionnaire that can be used to assess the different components of attitudes towards probability and its teaching. In a second step we plan to develop a wide evaluation study with prospective and in service teachers in Spain. In this paper we describe the first steps in building this questionnaire, that include the definition of the instrument components, the development of an item bank, the selection of the items in the scale using expert judgment and a preliminary pilot trial of the instrument in a sample of 71 prospective teachers. New data will be collected this semester and preliminary results of a first assessment study with prospective teachers will be presented at the conference.

THEORETICAL BACKGROUND

Theoretical and empirical issues related to attitudes have received some attention over the years, and different perspectives have emerged. In their analysis of the affective domain in mathematics education several authors discriminated between emotions, attitudes, and beliefs that differ by the stability of the affective responses that they represent, the degree to which cognition plays a role and the time they take to develop. Philipp (2007) described attitudes as manners of acting, feeling, or thinking that show a person's disposition or opinion towards a topic. They are relatively stable, comprise a larger cognitive component and less emotional intensity than emotions, develop as repeated positive or negative emotional responses and are automatized over time.

Attitudes towards a topic derive from positive or negative experiences over time devoted to learning that students may have had at school or in informal learning out of school or may transfer their feelings towards other topic, mathematics into probability (Estrada, Batanero, & Lancaster, 2011). They might influence a person's behaviour in relation to the topic inside and outside the classroom and their willingness to attend courses in the future (Pajares, 1996; Gal, Ginsburg, & Schau, 1997). This is particularly relevant in the preparation of teachers, since positive attitudes towards a topic would help them to understand that the topic is useful in their students' professional and personal lives, and that their students can be trained to understand this theme (Schau, 2003). In addition, statistics (or probability) teachers would be more likely to transmit to their students a positive view and an appreciation for the potential uses of the topic in future personal and professional life (Gal & Ginsburg, 1994). Additionally, Hannula (2002), distinguish four different aspects of attitude: emotions aroused in the situation, emotions associated with the stimuli, expected consequences, and relating the situation to personal values.

Following these and other authors, we conceptualized attitudes as a multidimensional concept. More specifically, after a cyclical process of revision of research dealing with attitudes we fixed three generally accepted components of the term "attitude" (Estrada, Batanero, & Lancaster, 2011; Gal, & Ginsburg, 1994; Gómez-Chacón, 2000; Ramirez, Schau,, & Emmioğlu, 2012; Schau, Stevens, Dauphine, & del Vecchio, 1995):

- *Affective component towards probability* (AP): Feelings about probability. For example, pleasure-displeasure towards this topic, interest-disinterest in the subject, possible rejection or anxiety.

- *Cognitive competence towards probability* (CCP): The person's self-perception as regards self-competence, knowledge, and intellectual skills when applied to probability. This component is very important in the case of teachers who need a good perception of their own ability for a particular subject.

- *Behavioural component towards probability* (BP): The person's inclinations to act towards the attitude object in a particular way, to make decisions, help other colleagues and use probability.

Since this scale is aimed at teachers we complemented the three classical attitude components with another three possible components of the attitude towards didactic aspects of probability:

- *Affective component towards teaching probability* (AT): Personal feelings about teaching

probability, which may vary (although be associated) with the affective component to the topic: pleasure-displeasure, fear-confidence, interest-disinterest, to teach probability.

- *Teaching probability competence component (CT):* This component assesses the teacher's perception of his her ability to teach probability, solve the students' problems, propose good work, seek resources, etc.

- *Behavioral component towards teaching probability* (BT): Rate the trend of didactic action: if the teacher has or not taught (or is willing or not) to teach probability; if he/she gives priority over other topics, if he thinks it should be postponed or reinforced.

Finally we have included a *Value component towards probability and its teaching* (VPT): appreciation of the usefulness, relevance, and importance of probability and its teaching in personal and professional life. Although we have found components of value, for example, in Schau et al, (1995), none of the scales analysed includes the value given for teaching.

DEVELOPING AN ATTITUDE SCALE

As in many educational or psychological variables, "attitude towards probability and its teaching" is unobservable. We therefore have to infer this knowledge from empirical indicators (the subjects' responses to the items in the scale (McDonald, 2013). In developing this scale we followed the following steps:

- *Semantic definition:* The first step in building such a scale was performing a detailed definition of the construct to elaborate its semantic definition. The variable to be measured (attitude) is not unidimensional, but its conformed by different components, that should be understood and analysed, and specified beforehand. This definition will serve later to study the instrument validity (Muñiz & Fonseca-Pedrero, 2009).

- *Components of teachers' attitudes towards probability:* we developed a structure with the seven components that were described in the previous section.

- *Item selection:* To identify suitable items that covered the questionnaire intended content, a preliminary pool of items was created by translating and adapting items from different research on attitudes towards statistics, sine we expect some relationship between attitudes towards statistics and towards probability. We examined the following scales:

  - *Statistics Attitude Survey* (SAS; Roberts & Bilderback, 1980) – the first instrument to measure attitude towards statistics. This scale was designed to be one-dimensional, with 33 Likert-type items.

  - *Attitudes Toward Statistics* (ATS; Wise, 1985). The ATS is a 29-item, Likert-type scale with five response possibilities consisting of two subscales. The *Field* (20 items) and *Course* (9 items) subscales respectively aim to measure attitudes towards the particular statistics course in which students are enrolled and the use of statistics in their fields of study.

  - *Survey of Attitudes Towards Statistics* (SATS; Schau et al., 1995). The scale consists of 28 items measuring four components: *Affect* (feelings concerning statistics), *Cognitive competence* (perception of self-competence, knowledge, and intellectual skills when

applied to statistics), *Value* (appreciation of the usefulness and worth of statistics in personal and professional life) and *Difficulty* (the perceived difficulty of statistics, as a subject). We also analysed a latter version (Schau, 2003), that also includes effort and interest components.

- *Multidimensional Auzmendi Scale* (1992): that considers attitudes towards mathematics and statistics at the same time. It includes five basic factors (usefulness, anxiety, confidence, pleasantness and motivation).

- *Scale of Attitudes Towards Statistics* (EAEE; Estrada, 2002) a specific scale directed to teachers that considers didactic aspects of attitudes. Its 25 items are distributed in three classical components (affective, cognitive and behavioural) complemented with other three anthropological components (social, educational and instrumental).

All these instruments are Likert scales with 5 or 7 graduations in the responses have been validated with university students and possess good reliability. After listing all the items in the different scales we adapted (to the case of probability and its teaching) those who a priori could be useful to assess one of our components. Each resultant item was analysed several times and compared with the intended content, with the help of some researchers who volunteered to provide feedback on the adequacy of potential items.

- *Item format and wording*. Once a set of 56 items was fixed (eight per component), their format and wording was revised. All of the items comprised statements in which the respondents scored their level of agreement or disagreement on a five-point Likert scale (from 1: strongly disagree to 5: strongly agree). We decided to use negative and positives sentences to avoid the problem of acquiescence and take into account different aspects of pedagogical and didactical components as described before. For example, the sentence "I enjoy the lessons in which probability is explained" is related to the affective component towards probability and strong agreement suggests a positive attitude in this component. At the same time the sentence "I never used probability outside mathematics" is related to a negative attitude in the behavioral component towards probability. Scores in items that are presented in negative form should be reversed, before the scale and component scores are formed by adding the scores in the different items

Component	Scale's Items
Affective component towards probability (AP)	1, 5, 16, 27
Cognitive competence towards probability (CCP)	6, 8, 17, 22
Behavioural component towards probability (BP)	2, 7, 15, 18,
Affective component towards teaching probability (AT)	9, 21, 28, 26
Teaching probability competence component (CT)	3, 10, 14, 23,
Behavioural component towards teaching probability (BT)	11, 20, 24, 25
Value component towards probability and its teaching (VPT)	4, 12, 13, 19

Table 1: Components and scale's items

Pilot trial.

Finally we tried the instrument in a pilot sample of 71 prospective primary school teachers in Spain. The average value per item ranged from 2.84 to 4.44; with mean 3.7 and standard deviation .42 (while the expected average value was 3.5). In the Appendix we present the mean score and standard deviation for each item (after recoding those with negative statements).

Item	Mean	Std. Dev.	Item	Mean	Std. Dev.	Item	Mean	Std. Dev.	Item	Mean	Std. Dev.
1	3.39	0.97	8	3.51	1.07	15	3.46	1.11	22	3.79	1.21
2	3.19	1.11	9	3.44	1.27	16	3.73	1.01	23	3.99	0.99
3	3.29	1.22	10	3.61	0.84	17	4.44	0.75	24	3.63	1.00
4	3.86	0.79	11	4.33	0.91	18	4.37	0.76	25	4.37	0.90
5	3.01	0.96	12	4.29	0.98	19	3.69	0.75	26	4.21	0.93
6	3.20	0.83	13	3.86	1.11	20	3.56	0.93	27	4.00	1.18
7	3.67	1.38	14	2.84	1.00	21	3.50	1.00	28	3.56	0.97

Table 2: Mean and standard deviation of the items in the pilot trial

The items which better scores (4 or more points on average) were item 17 (probability is understandable; $\bar{x} = 4.44$), item 18 (do not avoiding reading information that contains probability terms, $\bar{x} = 4.37$), item 25 and item 11 (no intention to suppress probability when teaching, $\bar{x} = 4.37$; $\bar{x} = 4.33$), item 12 (probability is useful apart games of chance; $\bar{x} = 4.29$), item 26 (being interested in teaching probability $\bar{x} = 4.21$) and item 27 (enjoying solving probability problems). Only item 14 (facility to prepare teaching materials, $\bar{x} = 2.84$) have an average score under the theoretical mean value. In consequence
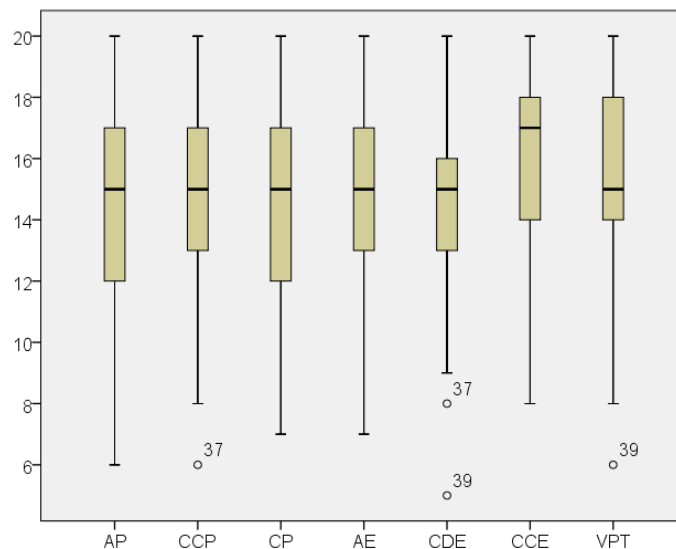

Figure 1: Box plots of scores in attitudes components in the pilot trial

Statistics for the total score and the different components are displayed in Table 2 and Figure 1 where we can see that attitudes in these teachers were positive in general and in the different components, in particular in their willingness to teach probability (BT) and the value attributed to probability and the teaching of probability to their students (VPT).

Variable	Mean	St. deviation	Variable	Mean	St. deviation
Scale	104.6	17.1	AT	14.7	3.1
AP	14.1	3.4	CT	14.7	2.7
CCP	14.9	2.9	BT	15.9	2.8
BP	14.7	3.3	VPT	15.7	2.6

Table 2: Mean and standard deviation of the total score and components in the pilot trial

DISCUSSION AND RESEARCH PERSPECTIVES

Although we only have obtained preliminary pilot data with this scale, results are encouraging as they show positive attitudes in those completing the scale. Not only the average scores were positive (higher than 3) in almost all the items, but the average scores in all the components were also higher than the theoretical mean value ($\bar{x} = 12$). These results contrast with those of studies measuring the prospective teachers' attitudes towards statistics. For example Begg and Edwards (19991) found negative attitudes in the affective component related to statistics, with the teachers expressing feelings like "fear" or "lack of interest". These teachers recognized the value of statistics, but did not consider themselves good with statistics. Estrada et al. (2005) found only moderately positive attitudes on cognitive competence (e.g., "I can learn statistics") and value (e.g., "Statistics is worthless") in a sample of 367 prospective primary school teachers in Spain with neutral or negative scores in the affect and difficulty components. Consequently our results suggest that prospective teachers' attitudes towards probability and its teaching may be better than those related to statistics and will favor the introduction of probability at schools as well as the teacher' interest for professional development in probability.

These results are likely to be replicated with other prospective teachers from the same context, as the instrument reliability was quite high (Cronbach's Alpha=.934) in the pilot trial. By the time of the conference we plan to complement these data with new applications of the instrument in bigger samples. This will allow also complete the statistical analyses and cross the results with some explanatory variables. In a second phase, we shall study the scale usefulness to compare attitudes of preservice and in-service teachers both in primary and secondary school level (our scale is not specific for a particular grade level. We also plan taking new samples from teachers in Latin American countries to analyse transnational studies

References

Auzmendi, E. (1992). *Las actitudes hacia la matemática estadística en las enseñanzas medias y universitarias* [Attitudes towards teaching mathematics in high school and university]. Bilbao: Mensajero.

Batanero, C. (2013). Teaching and learning probability. En S. Lerman (Ed.), *Encyclopedia of Mathematics Education* (pp. 491-496). Heidelberg: Springer.

Batanero, C. y Díaz, C. (2012). Training teachers to teach probability: Reflections and challenges. *Chilean Journal of Statistics 3*(1), 3-13.

Begg, A., & Edwards, R. (1999). Teachers' ideas about teaching statistics. *Proceedings of the 1999 combined conference of the Australian Association for Research in Education and the New Zealand Association for Research in Education.* Melbourne: AARE & NZARE. Online: www.aare.edu.au/99pap/beg99082.htm.

Estrada, A. (2002). *Análisis de las actitudes y conocimientos estadísticos elementales en la formación del profesorado* [Analysing attitudes and elementary statistical knowledge in the training of teachers]. *Unpublished Ph.D. dissertation*, Universidad Autónoma de Barcelona, Spain. Online: http://www.tesisenxarxa.net/TDX-0502103-191818/]

Estrada, A., Batanero, C., & Lancaster, S. (2011). Teachers' attitudes towards statistics. In C. Batanero, G. Burrill, & C. Reading (Eds.), *Teaching statistics in school mathematics. Challenges for teaching and teacher education* (pp. 173-174). Springer

Estrada, A., Batanero, C., Fortuny, J. M., & Diaz, C. (2005). A structural study of future teachers' attitudes towards statistics. In M. Bosch (Ed.), *Proceedings of the Fourth Congress of the European Society for Research in Mathematics Education* (pp. 508-517). Barcelona: IQS Fundemi. Online: ermeweb.free.fr/CERME4/.

Gal, I. & Ginsburg, L. (1994). The role of beliefs and attitudes in learning statistics: towards an assessment framework. *Journal of Statistics Education,* 2(2). Online: www.amstat.org/publications/jse/v2n2/gal.html

Gal, I., Ginsburg, L., & Schau, C. (1997). Monitoring attitudes and beliefs in statistics education. In I. Gal & J. B. Garfield (Eds.), *The assessment challenge in statistics education* (pp. 37-51). Voorburg, Netherlands: IOS Press.

Gómez-Chacón, I. (2000) Affective influences in the knowledge of mathematics, *Educational Studies in Mathematics, 43* (2), 149-168.

Hannula, M. S. (2002). Attitude towards mathematics: Emotions, expectations and values. *Educational studies in Mathematics, 49* (1), 25-46.

McDonald, R. P. (2013). *Test theory: A unified treatment*. Sussex, UK: Psychology Press.

MECD (2014). Real Decreto 126/2014, de 28 de febrero, por el que se establece el currículo básico de la educación primaria (Royal Decreet establishing the basic curricula for primary education). Madrid: Author.

Pajares, F. (1996). Self-efficacy beliefs in academic settings. *Review of Educational Research, 66*(4), 543-578.

Philipp, R. A. (2007). Mathematics teachers' beliefs and affects. In F. Lester (Ed*.), Second handbook of research on mathematics teaching and learning* (pp. 257-315). Charlotte, NC: Information Age Publishing y National Council of Teachers of Mathematics.

Ramirez, C., Schau, C., & Emmioğlu, E. S. (2012). The importance of attitudes in statistics education. *Statistics Education Research Journal, 11* (2), 57-71.

Roberts, D. M., & Bilderback, E. W. (1980). Reliability and validity of a statistics attitude survey. *Educational and Psychological Measurement*, 40, 235–238.

Schau, C. (2003, August). Students' attitudes: The other important outcome in statistics education. Paper presented at the Joint Statistical Meeting of the American Statistical Association, San Francisco, CA.

Schau, C., Stevens, J., Dauphine, T. & Del Vecchio, A. (1995). The development and validation of the survey of attitudes towards statistics. *Educational and Psychological Measurement, 55* (5), 868-875.

Wise, S. L. (1985). The development and validation of a scale measuring attitudes toward statistics. *Educational and Psychological Measurement*, 45, 401–405.

Appendix. Attitudes towards probability and its teaching scale

Note (Each item below should be followed by a 5-point scale ranging from 1 (strongly disagree) to 5 (strongly agree).

1. I enjoy the lessons in which probability is explained.
2. I use probability information when making decisions.
3. It will be hard for me to teach probability.
4. Probability helps you understand today's world.
5. I like probability; It is a subject that always interested me.
6. Probability is easy.
7. I never used probability outside mathematics.
8. I master the main contents of probability.
9. I am sure I will enjoy teaching probability in the school.
10. I think I can notice and corrrect the students' errors and difficulties with probability.
11. I will only teach probability if there is time available 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 will be easy for me to design assessment tasks related to probability.
15. I use probability in everyday life.
16. I feel cared when facing probability information.
17. Probability is understandable only for science people.
18. I avoid reading information that contains probability terms (e.g., in drugs prospects).
19. Probability knowledge help students to reason critically.
20. Probability should be taught since the first teaching levels.
21. I feel worried about being able to reply my students' questions about probability.
22. I do not feel well prepared to solve any basic probability problem.
23. I would not be able to prepare suitable didactic resources for the probability lesson.
24. I will use probability when needed in other topics I teach.
25. If I could skip a topic, I would suppress probability.
26. I am not interested in teaching probability, even if it appears in the curriculum.
27. I do not enjoy solving probability problems.
28. As a teacher, I would feel comfortable when teaching probability