Preparing pre-school teachers for teaching probability

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Abstract

Contemporary mathematics curricula introduce probabilistic activities as early as pre-school. Through a long term pre-school teacher professional development programme we tried to investigate pre-school teachers' beliefs about teaching probability in pre-school as well as their self-efficacy probabilistic teaching beliefs and whether these beliefs were possible to change. The programme was designed based on the assumption that teachers' beliefs, which are formulated through knowledge and experiences, inform and formulate their classroom practice. We worked with a small group, thus our findings can only be viewed as trends rather than generalizable conclusions. Nevertheless these findings show encouraging trends towards the verification of our initial assumption.

Keywords

Professional development, teachers' beliefs, pre-school mathematics, probability

Résumé

Notre recherche concerne un programme de développement professionnel des enseignants du préscolaire par rapport à l'enseignement des concepts de probabilité dans l'éducation préscolaire. Ce programme a eu aussi comme but d'améliorer les croyances par rapport à l'efficacité de l'enseignant. Des enseignants du préscolaire qui enseignent à l'éducation publique en Chypre ont participé en petits groupes à la conception et à la mise en œuvre d'activités sur des concepts probabilistes.

L'évaluation des données a montré la contribution de la formation au changement de confiance en soi des enseignants et de leur capacité à répondre à l'enseignement d'une telle matière.

Mots-Clés
Développement professionnel, croyances des enseignants, mathématiques préscolaires, probabilité

Introduction

Contemporary mathematics curricula often underline the importance of introducing probabilistic activities early in education, as early as pre-school (National Council of Teachers of Mathematics, 2000). This tendency considers the importance of probabilistic thinking, such as the understanding and interpretation of everyday phenomena, the contribution to other scientific areas, the development of the ability to justify decision making etc. Moreover, the introduction of probabilistic thinking to young children is based on current research activity which scientifically justifies young children's ability to conceive and understand probabilistic phenomena under the condition that such activities are developed within a meaningful pedagogical context (Kafoussi, 2004; Franklin et al., 2005; Jones, 2005; Skoumpourdi, Kafoussi & Tatsis, 2009; Batanero, Burrill & Readin, 2011; Batanero & Diaz 2012; Antonopoulos & Zacharos, 2013).

But without teachers' proper in-service professional development we cannot hope for positive results. Teachers' basic knowledge of statistical and probabilistic concepts plays an important role in quality teaching (Batanero et al., 2011). In order for teachers to acquire deep and meaningful understanding of such concepts, and use them in teaching, it is required that they systematically engage in relevant in-service training programmes, reflect on teaching these concepts and participate in designing and materializing such activities in class (Batanero & Diaz, 2012). It has been reported that teachers who have difficulty in materializing probabilistic experiments often unconsciously share their students' misconceptions and difficulties in probabilistic thinking (Batanero et al., 2011).

Mathematics education marks multiple levels of knowledge which teachers should incorporate in their professional status in order to be able to respond to current educational demands (Shulman, 1987, p. 8): "content knowledge; general pedagogical knowledge; curriculum knowledge; pedagogical content knowledge; knowledge of learners and their characteristics; knowledge of education contexts; and knowledge of education ends, purposes, and values". Specifically, in the area of probability, previous research has focused on aspects such as the educational potential of teaching probability (Batanero, Henry & Parzysz, 2005), teacher knowledge concerning probabilistic concepts (Stohl, 2005), teacher perceptions of randomness (Batanero et al., 2005), teacher and student

teacher attitudes and beliefs (Estrada, Batanero & Lancaster, 2011; Batanero et al., 2014), social, cultural and political aspects of uncertainty concepts (Greer & Mukhopadhyay, 2005), and of course the investigation of appropriate teaching approaches (Kafoussi, 2004; Jones & Thornton, 2005; Skoumpourdi et al., 2009; Antonopoulos & Zacharos, 2013).

The interest on teacher in-service programmes concerning stochastic mathematics gathers a continuous growth reflected in literature (Watson, 2001). The content of programmes aiming at in-service teacher development, their effectiveness and the evaluation of the processes are requirements which need to be met by teachers' professional development programmes. Improving teachers' professional status as well as the evaluation of in-service training processes are described by Sachs (1997) as a cyclical developmental course of assessment-action-reassessment.

The aim of our study was to introduce and evaluate a pilot Cyprus pre-school teacher in-service professional development programme concerning teaching probability. We believe that this study contributes to the literature base outlined in this paper. Moreover we consider this study to be of interest since it focuses on pre-school teachers' in service development concerning probabilistic teaching. To our knowledge, pre-school teachers have not been a specific group studied by research in the area of probabilistic teaching.

It has been noted that pre-school teachers, as well as teachers of the first years of primary school, are frequently apprehensive when invited to teach mathematical aspects demanding mathematical knowledge, they feel more comfortable teaching other curriculum subjects such as language for example (Copley, 2004). For these teachers, the teaching of mathematical concepts is considered a difficult subject of an unknown scientific area since they are often unaware of substantial mathematical processes, such as processes of reasoning or mathematical problem solving processes. Research shows that teachers' level of self-confidence is higher when they follow well-known teaching methods and familiar curriculum subjects than when they practice innovative methodological approaches and introduce new scientific concepts (Fullan, 1991; Ghaith & Shaaban, 1999; Kyriakides, 2005).

The introduction of probabilistic concepts in pre-school and early elementary school curricula is relatively new and teacher in-service programmes concerning such concepts show misalignments which are often caused by the distinction between teachers' intuitive approach and the actual mathematical formulation of probability (Borovcnik & Peard, 1996).

Children as well as adults' probabilistic judgment is often influenced by cognitive boundaries, personal preferences, religious or other beliefs (Piaget & Inhelder, 1975; Amir & Williams, 1999; Tarr, 2002). Research referring to teachers' professional development through educational programmes concerning the teaching of probability uses small participant samples and is limited. Nevertheless it gives useful ideas for such professional development programmes. Many researchers claim that many teachers having to teach

probability are not sufficiently qualified for such teaching (Begg & Edwards, 1999; Borim & Coutinho, 2008; Batanero & Diaz, 2012). Frequently teachers participating in professional development programmes concerning probability do not have the proper theoretical background and are not familiar with appropriate teaching methods concerning the area of probability. Moreover textbooks and guidelines accompanying school curricula concerning the area of teaching probability are not detailed enough (Batanero & Diaz, 2012). Lastly, research shows that teaching choices concerning probabilistic concepts depend on teacher concept knowledge (Ball, Lubienski & Mewborn, 2001). It is often noticed that in-service as well as student primary school teachers' knowledge concerning basic probabilistic concepts is insufficient (Begg & Edwards, 1999).

Affective domains about probability and its teaching

Teachers have their own perceptions in prioritizing not only curriculum subjects but teaching aims within a curriculum subject as well, a fact clearly viewed in their classroom practice. In other words affective domains such as beliefs, values, attitudes, and emotions play an important role in the process of teaching and learning mathematics (Grootenboer & Hemmings, 2007; Zacharos et al., 2007; Wilkins, 2008; Williams & Nisbet, 2014). Thus teachers' attitudes and beliefs concerning the general subject of mathematics as well as the implicit area of probability affect their teaching practices (Williams & Nisbet, 2014).

Attitudes are based on experiences and are relevant to a person's behavior towards something specific, for example a person's attitudes towards mathematics (Grootenboer & Hemmings, 2007). According to Relich (1993, in Grootenboer & Hemmings 2007, p. 5) "although definitions of attitude vary, they generally include the idea that attitudes are learnt, manifest themselves in one's response to the object or situation concerned, and can be evaluated".

Although attitudes are relevant to a person's favorableness or unfavorableness towards a psychological object their definition still remains unclear (Ajzen & Fishbein, 2000). In this paper, when we refer to the psychological definition of "attitude" we adopt the definition given by Ajzen and Fishbein (2000) where "attitude" refers "to the *evaluation* of an object, concept, or behaviour along a dimension of favour or disfavour, good or bad, like or dislike" (p. 3). In this case attitudes are defined directly without the need to re-examine information or beliefs on which they are based. Therefore, based on this definition, attitudes "tend to become active automatically in the mere presence of the attitude object" (p. 26).

Beliefs are referred to as mental representations influencing the practice of a person if and when the belief is active in cognition (Hunter & Markman, 2016). A mental representation is defined as information contained in the mind that is stored, or represented, in such a way that it can be used during cognitive processes (Markman & Dietrich, 2000). Thus a belief can be defined as a type of mental representation.

Teaching self-efficacy beliefs

A person's self-efficacy beliefs are related to his/her ability to organize and carry out specific tasks (Bandura, 1997). Teachers' self-efficacy beliefs can be defined as their perceptions about their ability to organize and practice teaching in a manner which advances their students' learning (Bandura, 1997).

Researchers acknowledge the dependency between teachers' self-efficacy beliefs about teaching mathematics and their students' performance (Chester & Beaudin, 1996). Teachers' self-efficacy perceptions play a vital role in their professional behaviour as well as in their student's performance since they are related to the teacher's classroom behaviour, his/her readiness to accept new ideas, his/her attitude towards teaching, his/her students' progress, and the way his/her students formulate their perceptions about schooling (Pajares, 1992; Soodak & Podell, 1996; Philippou & Christou, 1998).

Tschannen-Moran, Woolfolk Hoy & Hoy (1998) point out the need to focus educational research to certain aspects of self-efficacy underlining that teachers' self-efficacy regarding teaching a certain topic influences their actual teaching of that topic. Teacher's attitudes towards a specific curriculum subject as well as their self-efficacy beliefs are not easy to alter; attitudes and beliefs originate in deeply rooted perceptions resistible to change (Watson, Caney & Kelly, 2004). Nevertheless research shows that through learning and experience as well as through participation in professional development programmes, teachers strengthen their self-confidence and knowledge and alter their negative attitudes towards mathematics in general (Philippou & Christou, 1998; Hannigan, Gill & Leavy, 2013), as well as towards the specific area of probability (Williams & Nisbet, 2014). Teachers' participation in designing probabilistic activities offers the essential intrinsic motivations, such as autonomy increase, chances for positive reaction to the undertaken task and possibilities for colleague co-operation development (Baturo et al., 2007).

On teaching probability, Batanero and Diaz (2012) point out that teacher preparation should emphasize and deepen on the probabilistic concepts which are to be met in the school curriculum. This fact contributes to the modification of teachers' attitudes on the one hand and to the modification of their teaching self-efficacy beliefs, on the other.

Research questions

The study presented in this paper was a pilot study which aimed at introducing and evaluating the implementation of an in-service pre-school teacher professional development programme in the area of teaching probability. The research questions we set out to answer were:

1. Can the teachers' participation in a programme referring to the development of probabilistic thinking in pre-school, aiming at their familiarisation with basic probabilistic concepts as well as their involvement with designing and implementing

probabilistic activities in their classrooms, alternate their attitudes concerning the implementation of probabilistic activities in pre-school?

2. Can their initial probabilistic teaching self-efficacy beliefs be alternated through their participation in the programme?

Method

Research design

The research framework consisted of four phases (Table 1). During Phase 1 the participants were informed in detail about the aims of the programme and the way it would be implemented and were asked to fill in the initial questionnaire (details given below). During Phase 1 participants were encouraged to talk about their expectations concerning the programme and concerns about designing and implementing probabilistic activities in their classrooms. Phase 2 consisted of seminars during which (a) basic probability concepts were presented, (b) examples of the implementation of probabilistic activities in pre-school classrooms were presented, and (c) the participants began designing the probabilistic activities they would implement in their classrooms. The probabilistic activity design and implementation followed processes met in the mathematical problem solving process. More specifically the course followed in each activity to be implemented consisted of the stages of prediction, design of course to be followed, experimentation, result recording, and conclusion formulation (Shiakalli & Zacharos, 2012, 2014). During Phase 2 emphasis was given on group interactions- participants were encouraged to talk about their ideas and discuss them with the rest of the group in order to develop and enrich them. During Phase 3 the participants implemented probabilistic activities in their classrooms. During this phase each participant could meet with the researchers in order to (a) design probabilistic activities, (b) evaluate and re-design activities in order to re-implement them in the classroom, (c) discuss any matter concerning the implementation of probabilistic activities in the classroom. During the final phase (Phase 4) the participants met again in order to present the activities they had implemented in their classrooms to the rest of the group and discuss their experiences with the rest of the group. At the end of Phase 4 the participants were asked to fill in the final questionnaire which was the same as the initial questionnaire (see Appendix). As in Phases 1 and 2, participants were encouraged to discuss, evaluate and give feedback on their fellow participants' presentations.

Data analysis was based on the participants' answers to the initial and final questionnaire. Answer comparison before and after the implementation of the professional development programme gave us the opportunity to evaluate the contribution of the programme.

TABLE 1

The four phases of the research

Phase	Timeline	Description
Phase 1	November 11, 2013	Initial questionnaire answering
Phase 2	November 11 - November 18 2013 (two tree hour group meetings)	Mathematical seminars concerning : - basic probability concepts (probabilistic expressions, probability of a single event, probability of two independent events, conditional probability) - examples of the implementation of probabilistic activities in preschool classrooms - basic design of probabilistic activities to be implemented by the participants in their classrooms.
Phase 3	November 18, 2013 - February 8, 2014 (individual meetings arranged between teacher and researchers)	Participant implementation of probabilistic activities in their classrooms
Phase 4	February 8 - February 12, 2014 (two three hour group meetings)	Final questionnaire answering. Participant presentation of classroom implemented activities to the rest of the group.

The questionnaire

The questionnaire was developed based on other mathematics education questionnaires (TIMSS, 2007) and was adjusted to the needs of our research. It consisted of three sections (see Appendix): the first section- Section A (questions A1-A5) concerned the professional and scientific profile of the participants, while the second and third sections- Sections B and C (questions B1-B4 and C1-C9) identified the participants self-efficacy teaching beliefs concerning the area of probability and its implementation in pre-school. Section B consisted of semi-open questions in order to collect additional qualitative information about the participants' beliefs on probability and the development of probabilistic thinking in pre-school. The semi-open questions were codified as follows: (a) self efficacy beliefs in teaching probability in pre-school, (b) beliefs towards teaching probability in pre-school, (c) implementation of probabilistic activities in classroom practice. Section C consisted of closed questions concerning concepts similar to Section B, and their inclusion to the questionnaire was to verify the degree of consistency in the participants' responses.

Research participants

Eighteen pre-school teachers participated in the programme (Subjects 1-18 hereby referred to as S1-S18). The study sample was a convenience sample: participation was on a voluntary basis. An invitation was sent to all public pre-schools of the district of

Nicosia and teachers interested to participate registered for the programme. Data collected from Section A of the questionnaire showed that all participants were all female working at public pre-schools with professional experience between four and thirty years (mean 15.8 years, SD=6.2). Ten of the participants held a masters degree in pre-school education fields. The majority of the participants (14 subjects) participated in professional development seminars concerning mathematics education in pre-school. Half of the participants took part in seminars organized by a Cyprus University (public or private), while one subject and three subjects took part in seminars organized by the Pedagogical Institute or the Ministry of Education (amongst others) respectively. None of the participants had taken part in professional development programmes concerning probability.

The majority of participants (11 subjects) stated they had basic probabilistic knowledge: 7 participants acquired this knowledge in school while 4 participants acquired it during school and University.

In attempting to answer question A5 of the questionnaire, most participants gave descriptive and unclear aims for teaching probabilistic thinking in pre-school for example "the development of mathematical thought" (S2, S10, S11, S15), "the development of probabilistic thinking"(S13, S14;), "for the students to think about different possible solutions to a problem". Other participants seemed to have confused leaning aims with suggested teaching strategies (S8, S16, S18) while eight participants stated "I do not know" (S3, S4, S5, S6, S7, S9, S12, S17). Only one (S1) participant was able to give relatively clear aims concerning the use of probabilistic expressions by the children.

Findings

Self-efficacy teaching beliefs concerning the development of probabilistic thinking before the programme- (questions B1-B2 and C1-C4)

All participants believed they had insufficient knowledge concerning probability in order to teach it to their students (question B1). Participants' self-efficacy teaching beliefs, as demonstrated in question B2 ("How do you feel as a teacher expected to organize and develop probabilistic activities for pre-school?"), led to the following findings:

The perspective of participating in the programme seemed to have positively affected participants' answers concerning their expectations from the programme: for example S7 stated "it is a challenge to organize activities about a concept that is new to me and to the children", while for S9 working on a new concepts was viewed as "a chance for my professional development and a chance to enrich my knowledge and experiences". Moreover, the perspective of participating in a professional development programme seemed to have a positive effect on participants' professional confidence, as stated by the following participant (Caption 1).

Caption 1. *Co-operation and professional development perspective effecting self-efficacy teaching beliefs.*
S14: Generally, I am positive in carrying out classroom activities in co-operation with academics and researchers. This helps me acquire the necessary theoretical background, gives me the opportunity to co-operate with colleagues and receive feedback. Academics and researchers help me feel more confident when organizing classroom activities which will have a direct and positive effect on my students.

Teachers' positive beliefs were expressed through statements of satisfaction (two participants) and willingness to respond to the challenge of teaching the new mathematical area, a fact which is considered as a chance for professional development (seven participants).

But eight participants believed to be insufficient in teaching probability and expressed anxiety under the perspective of having to teach it in their classroom (Caption 2).

Caption 2. *Expression of anxiety and teaching insufficiency.*
S11: I am anxious because my students are three and four year olds. Moreover, I have no theoretical background to teach probabilistic concepts nor to develop probabilistic activities. This idea makes me even more anxious.

In one case (S18) mixed feelings were expressed as shown in Caption 3:

Caption 3. *Expression of mixed feelings.*
S18: The perspective of teaching probabilistic concepts excites me but at the same time makes me feel anxious and insecure as well.

Questions C1 to C4 investigated participants' self-efficacy teaching beliefs concerning the implementation of probabilistic concepts in pre-school. Question C1 referred to the teachers' self-efficacy teaching beliefs when expected to organize probabilistic activities. Seven (out of the eighteen) participants expressed anxiety under the mentioned perspective; six had no anxiety, while five stated having neutral feelings (neither positive nor negative).

Question C2 looked at self-efficacy teaching beliefs of participants who had already tried implementing probabilistic activities in their classroom (Question B1). Four participants (S8, S15, S16, S18) had tried materialising such activities before participating in the programme. Here we saw that only two (out of the four) participants felt satisfied by the organization and implementation of such activities while the other two stated that through their participation in the programme they came to the conclusion that the activities they had been implementing could not be considered as probabilistic activities (see Caption 8 quote of S18).

Looking at questions C3 and C4 only five participants (S8, S10, S11, S15, S16) felt self-confident enough to use children's comments as stimuli for probabilistic activities (question C3) while four (S1, S8, S10, S11) believed they could organize probabilistic activities for any school topic (question C4). Interestingly, S1, S8, S10 and S16 answered negatively when asked if they felt anxiety under the prospect of teaching probability (question C1) while S15 answered positively.

Attitudes on probabilistic teaching before the programme (questions B3-B4 and C5-C9).

The majority of participants (fifteen out of eighteen) answered positively to question B3: "Do you consider it useful for probability concepts to be introduced in pre-school?". Their positive response could be traced to the central positioning of mathematics and stochastic science in the world today. In some incidences it was considered as obligatory knowledge qualification for the demands of following school years and a trigger for children to create positive attitudes towards mathematics (Caption 4).

> Caption 4. *Preparation of following school years.*
> *S14.* Yes, the introduction of probabilistic concepts is useful in pre-school because it can create the base for better understanding of probability when children are confronted with it later in school. It can also contribute to the cultivation of positive attitudes.

Three participants who were positive towards teaching probability in pre-school stated (once again) that they had no knowledge of probability and how it could be taught in pre-school (question B1). One participant (S3) remained neutral in answering question B3, awaiting to formulate her opinion during the development of the programme (Caption 5).

> Caption 5. *Positive response under conditions.*
> *S3*: I do not know. I am waiting to see how the programme will turn out- the philosophy and methodology of teaching probability in pre-school. Nevertheless I find the idea intriguing.

All participants felt inadequate to teach probability in pre-school (question B1). Only four chose to try integrating it in their classroom practice (question B4). This finding is statistically important ($x^2=5.556$, $df=1$, $p<0.05$) showing that emotional variables, such as self-efficacy teaching beliefs were associated to participants' classroom practices, a fact also noted in our literature review (Tschannen-Moran et al., 1998; Williams & Nisbet, 2014). S9 stated: "I lack knowledge on how to organize my teaching on probability", while two participants (S4, S11) did not believe that pre-school children would be able to respond to probabilistic activities (e.g S4: "No. I have never organized probabilistic

activities because I thought that I would not be able to do it with such young children"). Even in the cases where participants had implemented probabilistic activities in their classrooms (S8, S15, S16, S18) they stated feeling discomfort and insecurity during the didactic manipulation of probability (Caption 6).

> Caption 6. *Doubts about adopted didactic practices.*
> *S18.* I tried implementing probabilistic ideas in my classroom. I found the idea and tempting. The lessons were interesting for me as well as for the children. But I felt insecure towards the validity of my activities as well as the way I guided the children.

Questions C5 to C9 also investigated participants' attitudes about the necessity of teaching probability in pre-school and whether they believed young children would be able to manipulate probabilistic concepts.

Most participants (twelve out of eighteen) considered teaching probabilistic thinking in pre-school to be interesting for the children (question C5), while all participants believed that occupation with probability could contribute to the development of children's general mathematical thinking (question C6).

Fifteen participants stated that the development of probabilistic thinking as early as pre-school was important (question C7).

Eleven participants found teaching probability in pre-school equally important as teaching traditional mathematical concepts such as geometry, number and arithmetic (question C8), while the remaining seven participants positioned themselves neutral in question C8.

Nevertheless, although participants considered probability to be interesting and useful for children and evaluated it positively for children's general mathematical thinking development, only four (S1, S8, S10, S11) believed that a programme consisting of a variety of probabilistic activities could be developed for pre-school (question C9).

Table 2 summarizes participants' answers to questions C1 to C9 both before and after the professional development programme.

The contribution of the programme

At the end of the programme participants were given a questionnaire (consisting of the same questions as the initial questionnaire leaving out questions A1-A4 which concerned participants' personal and professional status). We kept the numbering of the questions (of the final questionnaire) the same as the initial questionnaire for purposes of reference.

After the programme all participants were able to develop educational aims for the implementation of probabilistic activities in pre-school (question A5), as for example S5 who at the beginning of the programme stated she did not acquire this skill (Caption 7).

Caption 7. *Ability to develop educational aims concerning teaching probability in pre-school.*

S5. For the children to (i) properly use the correct probabilistic expression about a specific incident (always, never, might), (ii) define the sample space in single phase probability experiments, (iii) predict the outcome , graphically represent and interpret data concerning probabilistic experiments, and arrive at relevant conclusions (iv) recognize when an incident/game is fair/unfair.

Table 2

Attitudes about teaching probability in pre-school and probabilistic teaching self-efficacy beliefs

		Strongly disagree		Disagree		Neither agree nor disagree		Agree		Strongly agree	
		B*	A*	B	A	B	A	B	A	B	A
C.1	The idea of developing probabilistic activities causes anxiety to me	1	6	6	10	5		3	2	3	
C.2	I feel confident when planning and implementing probabilistic activities in pre-school.	4	1	5		7	1	2	14		2
C.3	I feel I can develop probabilistic activities through children's occasional comments	3		4		6		5	14		4
C.4	I could organize probabilistic activities for any school programme topic	4		2		8		4	10		8
C.5	Probabilistic activities are within pre-school children's' interests					4		12	5	2	13
C.6	Probabilistic thinking contributes to the development of general mathematical thinking							10	3	8	15
C.7	The development of probabilistic thinking is important					3		11	4	4	14
C.8	Occupation with probability in pre-school is equally important as occupation with traditional mathematical concepts such as geometry, number and arithmetic.					7		9	5	2	13
C.9	It is difficult to develop a variety of activities for probability in pre-school.		8	3	6	10		5	4		

* B: Before / A: After

Teaching self-efficacy beliefs after the programme (questions B1-B2 and C1-C4)

Our data showed that while initially all participants believed their knowledge to teach probability in pre-school was inadequate (question B1), after the programme all participants stated feeling adequate to implement probabilistic activities in their classrooms. The differentiation was statistically important (McNemar Test, $p<0.001$). Similarly, we saw a statistically important differentiation (McNemar Test, $p<0.01$) of all participants' beliefs concerning their probabilistic teaching efficacy (question B2) since they all felt confident to implement probabilistic activities having tried implementing them in their classrooms during the programme. That is, we detected withdrawal of the initial anxiety of the nine participants who at the beginning of the programme stated feeling anxious about having to teach probabilistic concepts in pre-school (Caption 8).

Change in participants' self-efficacy teaching beliefs concerning probability was also detected in question B2: all participants stated they felt confident to organize and develop probabilistic activities after having tried organizing, developing and implementing such activities to their classroom during the course of the programme. The anxiety we detected initially (in nine participants) seemed to have given its place to confidence (Caption 8).

Caption 8. *Differentiation of teaching probabilistic self-efficacy beliefs.*

S7. Now I feel that I have adequate knowledge in order to organize and implement probabilistic activities in pre-school. It is a new and interesting filed for me and for the children through which they can acquire useful mathematical skills. Having implemented probabilistic activities in my classroom -as part of this programme- I saw children's positive responses and this gives me the motive to continue implementing probabilistic activities in the future.

S14. At the beginning I was anxious. During the programme, while trying out probabilistic activities in class and being in constant co-operation with the researchers, I felt more confident. Towards the end of the programme I started feeling more confident. Now I feel good about my work and the activities I implemented in my class.

S18. First of all I feel that the content of teaching probability in pre-school is now clear. Before the programme I believed I was implementing probabilistic activities in class, now I realise I was not. I do not feel anxious about organising and implementing probabilistic activities in my class any more. But I feel I need more experiences concerning probabilistic activities because I realise that sometimes I find it difficult to formulate specific aims concerning probabilistic concepts. This is why I believe it is important for this in-service professional programme to continue to a next level.

After the completion of the programme participants stated they were less anxious in organizing and implementing probabilistic activities in their classrooms (question C1). While twelve participants initially stated feeling anxious or reluctant, eleven of them stated not having these feelings at the end of the programme. The differentiation in their answers was evaluated as statistically important (Wilcoxon, $p<0.001$).

While fifteen participants were reluctant or negative towards trying to implement probabilistic activities in class (question C2) before the programme, after the programme their attitude was shifted to positive showing a statistically important differentiation (Wilcoxon, $p<0.001$).

Participants' answers to question C3 where also differentiated, showing a statistically important shift (Wilcoxon, $p<0.001$): the thirteen participants who felt inadequate or unable to develop and implement probabilistic activities for their class before the programme now felt they could draw examples from everyday school life and children's occasional comments in order to develop probabilistic activities.

Lastly, after the programme we found a statistically important differentiation (Wilcoxon, $p<0.001$) in participants' self-efficacy teaching beliefs since they all felt capable of organizing probabilistic activities for any school topic (question C4). More specifically the fourteen participants who initially felt doubtful or incapable of integrating probability in any school topic now felt self-confident and capable to do so.

Attitudes about teaching probability after the programme (questions B3-B4 and C5-C9)

In Question B3 we tried to detect participants' attitudes towards the usefulness of introducing probabilistic activities in pre-school. At the beginning of the programme three participants stated their reservations. By the end of the programme these reservations were lifted: in the final questionnaire all participants stated they believed in the usefulness of implementing probability in pre-school. In substantiating their view they formulated a refined argument- we quote S5 (Caption 9) who in her initial questionnaire showed to be reluctant in introducing probability in pre-school.

> Caption 9. *Educational importance of teaching probability.*
> *S5*. Yes, it is useful to introduce probabilistic activities in pre-school because through such activities children develop basic mathematical skills such as observation, data recording, data interpretation and prediction.

In comparing participants' answers in question B4 ("Have you ever implemented probabilistic activities in pre-school?") before and after the programme, we found a qualitative and quantitative differentiation: the fourteen participants who initially stated they had never tried implementing probabilistic activities in pre-school now answered positively (statistically important differentiation, McNemar, $p<0.01$) while the four

teachers who had answered question B4 positively in the initial questionnaire clarified that now they organized and carried out the activities under a different light (see Caption 8, quotation S18). Here we found a differentiation in the four participants' self-efficacy teaching beliefs who while having implemented probabilistic activities before the programme still stated that the prospect of organising and implementing such activities caused them anxiety (see Caption 6). The following Caption (Caption 10) outlined this point:

> Caption 10. *Differentiation of self-efficacy teaching beliefs after the programme.*
> *S18*. Yes, it was very interesting. The children had fun and wanted more. Most children's interest and attention remained at high levels throughout the lessons! When I saw the children asking for more and suggesting new ideas I was delighted!

In Question C5 (concerning the participants' attitudes of whether probabilistic activities are interesting for young children) participants answers at the end of the programme significantly moved to more positive levels (Wilcoxon, $p<0.001$). In the final questionnaire all participants, even the four who were initially reluctant answering neutrally, stated they agreed (4 participants) or strongly agreed (18 participants). Similarly, participants' answers after the programme shifted towards more positive levels (Wilcoxon, $p<0.05$) in Question C6: eight out of the ten participants who initially agreed that probabilistic activities can help in the development of general mathematical thinking now strongly agreed.

In Question C7, whether the development of probabilistic thinking in pre-school is important, participants' answers after the programme shifted towards more positive levels (Wilcoxon, $p<0.001$)- all participants, even the three who initially answered neutrally, now stated they strongly agreed. Similarly participants' attitudes that dealing with probability in pre-school is as important as dealing with other "traditional" aspects of mathematics (question C8), moved to more positive levels (Wilcoxon, $p<0.001$) after the programme. The seven participants, who initially answered neutrally, now stated they agreed (3 participants) or they strongly agreed (4 participants).

Finally, in Question C9 (whether it is difficult to develop a variety of probabilistic activities in pre-school) participants' attitudes shifted interestingly: out of the five participants (S2, S3, S8 , S17, S18) who initially agreed with the statement now two disagreed (S3, S18) and two strongly disagreed (S2, S8) while S17's belief remained stable. Out of the ten participants (S4, S5, S6, S7, S9, S10, S11, S13, S14) who were initially neutral (neither agree nor disagree) now one strongly agreed, two agreed, four disagreed and three strongly disagreed. Therefore, eleven out of the fifteen participants who initially gave neutral or positive answers now stated they disagreed or strongly disagreed with the statement in C9, allowing us to evaluate the shift as statistically important (Wilcoxon, $p<0.001$).

Conclusions and discussion

This paper deals with an in-service pre-school teacher professional development programme and looks at its outcomes. The programme focused on the implementation of probabilistic activities in Cyprus pre-school settings. Before the programme participants' had no or little knowledge of the teaching aims of probabilistic thinking in pre-school (Question A5).

Concerning the first research question, we found that while the majority of participants considered integrating probability important (Questions B4 and C3, Caption 4), claiming that probability could attract children's interest (Question C1) and contribute to their general mathematical thinking development (Questions C2 and C4), only four participants had tried implementing probabilistic concepts in their classroom practice before the programme (Question B3). But even those participants expressed doubts about the correctness of their teaching practices (Caption 6). By the end of the programme the shift towards more positive answers was noticeable (Caption 9). The same shift was noted in participants' final answers concerning their attitudes whether (a) probabilistic activities are interesting for young children (Question C5), (b) probabilistic activities can help in the development of general mathematical thinking in re-school (Question C6), (c) the development of probabilistic thinking in pre-school is important (Question C7), (d) dealing with probability in pre-school is as important as dealing with other "traditional" aspects of mathematics (Question C8) and, (e) it is difficult to develop a variety of probabilistic activities in pre-school (Question C9).

Concerning our second research question we found that, initially, participants' beliefs about their self-efficacy in teaching probability were strongly negative. These beliefs were accompanied by anxiety and insecurity. This was particularly evident in Question B1 (Caption 2). The perspective of including probability in their classroom practice caused anxiety to seven out of the eighteen participants (Question C1). Anxiety was often related to doubts about their teaching efficacy (Caption 6). Anxiety was also detected in the few participants who had tried materializing probabilistic activities before the programme (Question C2). Moreover, while through their participation in the programme participants seemed to be looking forward to their professional development (Captions 1 and 5), the prospect of teaching probability within the guidelines of the programme created mixed feelings (Caption 3).

The correlation between participants' responses to Question B1 (self-efficacy probabilistic teaching beliefs), and Question B3 (materialisation of probabilistic activities) appeared to be statistically significant: participants who had negative self-efficacy probabilistic teaching beliefs at the beginning of the programme were the ones who did not try to implement probabilistic activities in their classrooms before the programme. Our findings agree with studies mentioned in our literature review (Tschannen-Moran

et al., 1998; Williams & Nisbet, 2014) where it is mentioned that emotional variables, such as self-efficacy teaching beliefs, affect teaching practice.

Our data showed that pre-school teacher' participation in theoretical seminars concerning the presentation of school probability, their involvement in the workshops concerning probabilistic activity design as well as the implementation of such activities in their classes significantly contributed to the modification of the participants' self-efficacy probabilistic teaching beliefs. Therefore, our second research question can be answered positively. It should be noted that, according to our data, even the perspective of participating in the programme contributed to the modification of participants' self –efficacy probabilistic teaching beliefs (Caption 1). This is because participation in an in-service professional development programme seemed to give participants the opportunity to be informed about the main concepts and methodological considerations concerning probabilistic thinking in pre-school (Caption 7).

Our data showed that all participants modified their self-efficacy teaching beliefs from negative or neutral to positive or strongly positive; in all cases this modification was statistically important (Questions B1-B2, C1-C4, Caption). We also found a significant modification in participants' attitudes concerning the way they dealt with probability suggesting that they had started withdrawing their initial doubts and hesitation concerning teaching probabilistic concepts in pre-school (Caption 9).

Our findings agree with similar studies (see literature review) which underline the contribution of in-service professional development programmes to the modification of teachers' attitudes and beliefs in mathematics and its teaching in general (Philippou & Christou, 1998) as well as in the specific area of probability (Baturo et al. 2007; Batanero & Diaz, 2012; Williams & Nisbet, 2014).

Limitations and prospects

In our study, due to the (a) absence of a control group, and (b) non-probability sample, (c) quasi experimental design findings can be used in order to strengthen trends detected in similar studies rather than generalize conclusions.

Moreover there are theoretical and methodological parameters requiring further investigation. For example, the correlation between beliefs and teaching practices suggests an attempt for ontological attribution to emotional parameters such as attitudes and beliefs, a fact that seems to satisfy the need to interpret human behavior on a cause-and-effect basis. But in the case that we accept the ontological existence of attitudes and beliefs, the process of causing individuals to reveal them is a desired goal (Ruffell, Mason & Allen, 1998). This concept creates the need for extending research methods, especially in qualitative approaches (Vacc & Briht, 1998) and intensifying in individual mathematical areas (Peterson et al., 1989) which we expect to give a fuller

and more valid recording of teachers' views on school mathematics aspects and their teaching.

Thoughts on pre-school teachers' mathematical education

In this paper our aim was to create a programme focusing on pre-school teachers' professional development in the area of probability. We intended to identify and comprehend the specific pre-school teachers' beliefs concerning probability and its teaching, creating a context for dialogue within which professional development programmes, through the necessary reforms, could become more effective. We believe that pre-school teachers' in-service professional development programmes should at least consider the following:

Firstly the type of transformation that knowledge should undergo, through research on mathematics education and is to become subject of teaching for professionals working with young children. Such teaching transformation should, in our opinion, be based on pre-school teachers' scientific background and on the required professional abilities needed for teaching mathematics at that specific educational level and be offered within a context which strengthens the cultural characteristics of mathematics education. This means that efforts should be focused on extracting mathematical content from everyday practices which appear in a pre-school classroom as well as the inclusion of mathematical activities within a meaningful context in order to facilitate effective teaching.

Secondly, research shows (Copley, 2004) that education professionals' involvement in interactive situations, where a variety of approaches appears, reduces their reluctance while increases their confidence. This was the case in our study: during our last meeting with the participants we asked them to write down their impressions of the programme and what was repeatedly demonstrated was the dominant co-operative environment during the development of the programme, within which ideas were shared and discussed. We consider the following quote (S10) characteristic: "the fact that all sessions included discussion as well as the communication developed between us as participants made the difference. We could exchange ideas with colleagues, discuss them and, more importantly, compare our work with each other. This type of interaction is important". Moreover, participants' communication and discussion with trainers and academics (research team) increased their confidence as shown in the following quote (S18): "I specifically enjoyed the fact that apart from participant interaction we also had continuous interaction with our trainers. We could meet with them at any time and discuss our thoughts, ideas, fears and concerns. This was something new to me and I really liked it. Throughout the programme I felt that I had someone who was more

knowledgeable and had more classroom experience than me, who could guide me, listen to and understand my concerns and help me overcome any difficulties".

Conclusively, co-operation between pre-school professional practitioners can lead to (a) transfer of experiences which often can decrease their anxiety about mathematics and its teaching and (b) finding that their doubts and concerns are not personal but shared by fellow pre-school teachers as well.

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QUESTIONNAIRE

A. Scientific and professional status

A1. Years of teaching experience: ……..……

A2. Studies

Masters	☐	Field:……
Second degree	☐	Field: ……
PhD	☐	Field: ……
Other	☐	Specify: ……

A3. (a) Have you participated in in-service professional development programmes concerning pre-school mathematics education? Yes ☐ No ☐

(b) in the case that you have participated in any kind of in-service professional education program, in the area of mathematics education, specify the organizer and the topic/s

☐ Ministry of Education and Culture - Topic/s: ……

☐ Paedagogical Institute - Topic/s: ……

☐ University Institution - Topic/s……

☐ OMEP(NGO) - Topic/s……

☐ Other - Topic/s ……

(c) Have you participated in in-service professional development programmes concerning probability in pre-school education? Yes ☐ No ☐

A4. (a) Have you any knowledge of probability? Yes ☐ No ☐

(b) if yes, where did you acquire this knowledge?

As a student in school ☐

As a university student ☐

Other ☐ Specify……..

A5. Assume you are going to implement probabilistic activities in your classroom during the current school year. Which would be your general aims should be?

……

B. Beliefs on the area of probability and self-efficacy beliefs

Self-efficacy beliefs

B1. Do you consider having adequate probabilistic knowledge in order to teach probability in pre-school?

Yes ☐ No ☐

B2. How do you feel as a pre-school teacher who is expected to organize and develop probabilistic activities for class?

……

Beliefs on probability

B3. (a) Do you consider it useful for probability concepts to be introduced in pre-school?

Yes ☐ No ☐ I do not know ☐

(b) Why; ……

B4. Have you ever implemented probabilistic activities in your class?

Yes ☐ Describe your experience ……

No ☐ Why ……

C. Beliefs on teaching probability (C1-C5) and self efficacy teaching beliefs (C6-C9)

		Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
C1	The idea of developing probabilistic activities causes me anxiety					
C2	I feel confident when planning and implementing probabilistic activities in pre-school.					
C3	I feel I can develop probabilistic activities through children's occasional comments					
C4	I could organize probabilistic activities for any school programme topic					
C5	Probabilistic activities are within pre-school children's' interests					
C6	Probabilistic thinking contributes to the development of general mathematical thinking					
C7	The development of probabilistic thinking is important					
C8	Occupation with probability in pre-school is equally important as occupation with traditional mathematical concepts such as geometry, number and arithmetic					
C9	It is difficult to develop a variety of activities for probability in pre-school					