PRESCHOOLERS' INTUITIVE PROBABILISTIC THINKING DURING OUTDOOR PLAY

ZOI NIKIFORIDOU
University of Ioannina
znikifor@uoi.gr

JENNIE JONES
Liverpool Hope University
18010501@hope.ac.uk

ABSTRACT

Young children encounter uncertainty and challenges on a daily basis; through their intuitions, experiences and experimentation they construct knowledge, skills and dispositions towards probabilistic concepts. The aim of this exploratory ethnographic study is to identify how young children engage with probabilistic thinking and reasoning while playing outdoors. Twelve 3–4-year-old children and two practitioners were observed during free and structured activities outdoors. Critical events, that reflect contexts of probability, chance and uncertainty, were identified for further analysis based on participants' linguistic interactions. Children's probabilistic thinking was mainly expressed in three instances: while solving problems, in creative play, and while considering risk and safety issues. These authentic understandings can become the basis for more instructional pedagogical sequences on probability in early years.

Keywords: *Statistics education research; Early childhood; Probabilistic thinking; Verbal expressions*

1. INTRODUCTION

Over the last 20 years, there has been an ongoing interest in exploring the characteristics of children's probabilistic thinking in formal and informal contexts in early years (e.g., Greer, 2001; Kingston & Twohill, 2022; Nikiforidou, 2018). From more classical theoretical and research paradigms (Fischbein, 1975; Piaget & Inhelder, 1975) to more contemporary studies, there is consensus that probabilistic literacy is necessary for citizens of all ages to enable them to actively engage in a multimodal world characterised by data and uncertainty (e.g., Bargagliotti et al., Batanero et al., 2016; 2020; Leavy et al., 2018; Martinez & LaLonde, 2020). Despite initial estimations that elements of probabilistic understanding are minimal or absent in young children, recent research has shed light as to how intuitive and spontaneous (everyday) concept formation can enable children to engage with probabilistic ideas and notions in a more sophisticated way. It is through probabilistic information and early probability learning that children and infants interpret the cues from their environments and develop an understanding of associations (Denison & Xu, 2014; Kushnir et al., 2010; Waismeyer et al., 2015).

The linkage between informal and formal learning in the early years remains a field of ongoing development and significance. Therefore, there have been attempts and initiatives in incorporating probabilities in early childhood mathematics or statistics curricula. These attempts, however, are not commonly shared or straightforward. Groth et al. (2021) mentioned that the role of probability in early childhood education has fluctuated greatly and there was a lack of agreement as to how early probability learning can be embedded effectively in practice. Similarly, Leavy et al. (2018) agreed that despite the importance of developing young learners' early statistical and probabilistic reasoning, the evidence base to support such development was scarce.

Statistics Education Research Journal, 22(2), Article 2. https://doi.org/10.52041/serj.v22i2.444

To explore these issues further, the ethnographic study reported in this paper aimed to record young children's authentic consideration of probabilities through free and/or structured episodes of outdoor play. Children's narrations and oral expressions while confronting events characterised by uncertainty are analysed, aiming to showcase how they understand, feel and think intuitively and non-scientifically in such instances. Interactions among children and among practitioners and children during their daily practice outdoors are examined. These everyday responses intend to reveal elements of children's probabilistic thinking accounting for a connection to the development of more formal, operational and analytical reasoning in the pre-schooling setting.

1.1. CONCEPT FORMATION AND INTUITIONS: THEORETICAL ORIGINS OF PROBABILISTIC THINKING

The emergence of probabilistic thinking and the development of the notion of chance was originally studied by Piaget as part of his broader theory on cognitive development (Piaget & Inhelder, 1975). He supported the notion of a developmental trajectory, where at the concrete stage, after the age of 7 years, is when children develop schemas of combining possibilities. At this stage, children can master their cognitive capacity to understand irreversibility, deduction, random mixing, and random distribution. Piaget (1951 as cited in Piaget & Inhelder, 1975) supported that earlier in life, children can make probabilistic judgments but these are based on specific operations and spontaneous concepts: what they see happening in their immediate experience (phenomenism), what they subjectively think and believe happens (egocentrism), and what just preceded (passive induction). From the Piagetian perspective, these original concepts of uncertainty develop as complementary to logical operational structure and through age and experience wither away. Thus, Piaget drew a fine line between the child's own ideas of reality constructed through personal mental efforts (spontaneous) and the ideas that are influenced by adults (nonspontaneous).

Vygotsky (1962) questioned Piaget's approach to this dichotomous nature of the two types of concept formation. He proposed that the child's thoughts do not get replaced gradually by what is absent and non-existent, Vygotsky also refuted that there is a process of antagonism and compromising between spontaneous and nonspontaneous concepts. Instead, he examined how spontaneous (everyday) and scientific (nonspontaneous) concepts emerge and become interdependent through a unitary process. Spontaneous concepts derive from experience and become gradually conscious, whereas the scientific concepts are schematic but lack the rich content of personal meaningfulness. Thus, the concepts develop in reverse directions, where "the development of the child's spontaneous concepts proceeds upward, and the development of his scientific concepts downward" (Vygotsky, 1962, p. 108). These are closely connected and although they start apart, they move to meet each other, mainly through instruction. The spontaneous concepts are not conscious or deliberately applied at the beginning and they develop through concrete, experiential situations, habits, and skills. Scientific concepts, in turn, begin from their verbal definition and use in non-spontaneous operations and grow downward. These two kinds of concepts are personally, socially and culturally situated and their very nature presupposes a system requiring coordination of thoughts.

Regarding the study of probability, Fischbein (1975) underlined the role of intuition and instruction. Primary intuitions are cognitive acquisitions formed by experience before systematic instruction and precede secondary intuitions that are grounded on correct computations and scientific instructions. Fischbein raised the necessity to distinguish between the two, as this "polar pair of intuitions, chance-necessity, is largely a part of adaptive behavior of the child" (p. 71). In discussing the interconnection between primary and secondary intuitions, through the role of instruction and the wider educational context, he added that primary intuitions need to be gradually adapted and expanded beyond their initial narrow range of applicability. Furthermore, secondary intuitions can be established through active interaction with probabilistic phenomena and representational resources in the school environment. Thirdly, primary intuitions do not disappear (Fischbein, 1987, p. 38), but instead continue to influence judgments. Overall, intuitions according to Fishbein, are manifested in preschoolers and get adapted and stabilised gradually through the interplay of social learning and personal experience.

As mentioned by Hawkins and Kapadia (1984) "… Fischbein is looking for the existence of partially-formed probability concepts whereas Piaget is observing the lack of completed concepts" (p. 352). Vygotsky (1962), who did not work on probability per se but concept formation in a broader sense, proposed that both types of spontaneous and scientific concepts could work through an interdependent, reciprocal way. In the early years, specifically during early experiences in the preschool setting, there could be foundations that connect non-scientific, intuitive thinking to more formal operational reasoning and vice versa. Children bring in the preschool environment subjective accounts and representations of chance, uncertainty, risk, possibility, and probability that in turn can trigger more advanced reasoning; the most effective pedagogical practices through which this might happen, is a field of ongoing interest and importance.

1.2. PROBABILITIES IN THE EARLY CHILDHOOD EDUCATIONAL CONTEXT

According to Martinez and LaLonde (2020), attitudes, skills and ideas about statistics and mathematics form early, so it is critical to ensure that students have positive and meaningful statistics and data science education experiences as early as possible. These are necessary for setting foundations for statistical reasoning and literacy in a meaningful way, within formal and informal contexts. Bargagliotti et al., 2020) underlined, "Students need to begin at an early age to become data-savvy, whether working with small data sets or large, messy data sets, traditional data, or non-traditional data such as text or images" (p. 3).

According to Threlfall (2004), probability content in the pre-school and early school years involve statements on probability language, answering probability or likelihood questions about data provided, or answering probability or likelihood questions about a described situation, and collecting and reflecting on empirical data. HodnikČadež and Škrbec (2011) reiterated that probability content can be introduced in the early school period, through children's active participation in discussions on situations that are possible, impossible, likely, unlikely, less probable, equally probable, through experimentation and through the use of concrete materials. Similarly, in regard to design and teaching methods, Nikiforidou (2019) found that for young children the use of tangible materials in exploring probabilistic notions leads to more accurate estimations compared to computer-based ones. Groth et al. (2021) agreed that the question is not if probability should be studied by young children, but rather how it ought to be studied. They called for more research on early probabilistic learning and proposed a structure for early probalistic thinking (SEPT) framework. The SEPT framework provides direction for further theorisation and curriculum development related to ikonic mode probabilistic thinking, which is relevant to the early years of learning.

Batanero et al. (2016) also called for more research in outlining young children's preconceptions and intuitions in relation to new probability content in school curricula. They acknowledged that probabilities are included in curricula and in teacher training, however, the presence of a topic in the curriculum does not automatically mean appropriateness and effectiveness in teaching and learning. They mentioned that it is important to reflect on the age, the previous knowledge of students, appropriate teaching methods, and suitable teaching situations. A few studies (e.g., Girotto et al., 2016; Nikiforidou et al., 2013) have examined young children's intuitive accounts of data and probability sense before formal education. Likewise, the current study aims to investigate children's authentic verbal expressions and representations of probabilistic notions during outdoor play.

1.3. ETHNOGRAPHIC APPROACHES IN EARLY CHILDHOOD

Ethnographic studies aim to understand reality by focusing on daily experiences and the everyday life of people. The aim of ethnography is to explore ordinary social or cultural realities, routines, and processes through observations. Ethnography draws explicit attention to the social and cultural context of life and highlights that the group is much more notable than the individuals involved in it. Ethnographic research, according to Hammersley and Atkinson (2007), investigates social processes in naturalistic environments, is multi-stranded and is characterised by distinctive features. "The ethnographer participates, overtly or covertly, in people's daily lives for an extended period of time, watching what happens, listening to what is said, asking questions; in fact, collecting whatever data are available to throw light on the issues with which he or she is concerned" (Hammersley & Atkinson, 2007, p. 3). As such, ethnography provides an in-depth qualitative way of collecting data stemming from participants' lived experiences, understandings, motivations, and aspirations.

In recent years, ethnography has been considered more within the field of early childhood. It is underlined that ethnographic approaches can "provide holistic accounts that include the views and perspectives, beliefs and values of all those involved on the particular sociocultural practice or institutional context" (Siraj-Blatchford & Siraj-Blatchford, 2001, p. 193). Ritchie (2020) agreed that the possibilities ethnography offers are valuable and necessary in enlightening understandings derived from diverse socio-cultural microcosms. She acknowledged that ethnography in early childhood education is not just "a way of looking and a way of seeing" (Wolcott, 2008, p. 41), but instead it is also a way of listening through giving voice to young children, families, communities, and teachers as "social actors" (James, 2011) of their own worlds.

Similarly, in the context of social sciences, ethnography has shifted beyond the human aspect, by targeting the role and relational connection between materiality, sensation, affect and the more-than-human (Ingold & Palsson, 2013; Pink, 2015). This approach challenges the dualism of nature versus culture, repositioning the connections among mind, body and environment through rich, detailed descriptions of the complex interactions occurring. As such, ethnographic research systematically analyses the perspectives and experiences of participants through personal and cultural patterns that inform their ways of being, knowing, doing, and relating.

The study reported in this paper aimed to apply an ethnographic approach in identifying how 3–4-year-old children narrate, feel, and behave in play situations that encapsulate uncertainty. Participant observations were conducted to explore children's lived experiences and daily encounters while playing outdoors, focusing on aspects of the children's probabilistic thinking and reasoning. Questions explored were:

> How do children face uncertainty and express probability in authentic, naturalistic contexts?
>
> How are their spontaneous, non-scientific concepts and intuitions expressed and shared?

2. METHODOLOGY

2.1. SETTING, DESIGN AND PARTICIPANTS

This study took place in a daycare nursery in North West England, which was recognised as a Forest School provider (https://youtu.be/ilsipn-rE2Q). The outdoor setting was the basis of all video-recorded observations and entailed a large space surrounding the main building. The front part consisted of a rather natural area, which enabled activities like den building, baking a mud pie, building a campfire and consisted of a wooden pirate ship, trees, bushes, rocks and logs that circled a "once upon a time" wooden chair. In addition, there were additional play resources like plastic plates and cutlery, golden treasure coins, a hose, spades and other miniature gardening equipment, as well as natural items like stones, cones, leaves, sticks. Children played daily in this space that was approximately 30 × 20 metres. The back part of the outdoor space was paved and smaller in size, with flat wooden tables and other resources offering children opportunities to work on a more one-to one basis with carers. In this part more supervised activities took place, like using hammers or pipes to observe the water flow or gardening.

The researchers familiarised themselves with the children of a specific class in advance of the study and contributed to discussions and play invitations received. Data were collected through a series of participatory observations of children (n = 12) and practitioners (n = 3) through four visits at the setting. The children who participated were aged 3–4 years-of-age, including three girls and nine boys. The practitioners had an average of five years' experience and were Level 3 qualified Forest School practitioners. Before data collection commenced, all parents or guardians of the children and the practitioners were informed about the rationale of the study. Voluntary participation, anonymity, confidentiality, and the right to withdraw at any stage of the study were communicated to ensure the research met all the health and safety protocols of the setting in which data were to be collected. The parents or guardians gave informed consent for their children to participate. After consent was provided, the children of the cohort were informed about the observations and were encouraged to express whether they agreed to participate or not. All 12 children of the class and the three practitioners were happy to take part. The researchers involved had working with children checks and previous extensive experience in working with young children.

Observations took place once per week at the same time and overall lasted 142 minutes. The observations captured children's interactions and behaviors in their everyday outdoor environment during both free and more structured activities. The free activities were child-led and rather unstructured based on children's flow, choices, initiatives (e.g., making dens or baking mudpies) and the more structured activities were adult-led aiming at specific learning outcomes (e.g., making a stickman or lighting up a campfire to roast marshmallows). Children's and practitioners' dialogues and verbal expressions were video recorded during the observations and transcribed for analysis. The analysis of data was based on critical incidents related to probabilistic events. For the purposes of the study, we identified as probabilistic events the instances where uncertainty was dominant allowing participants to think of or express possibilities and inferences.

2.2. CRITICAL EVENTS OF PROBABILITY SITUATIONS

The children's and practitioners' use of language was transcribed from the video-recorded observations was used for analysis, which aimed at shedding light to children's intuitive and spontaneous thinking. During the analysis, the presence/absence of materials and manipulatives was also considered in addressing their role and significance in instances of probability and chance (Nikiforidou, 2019). The analysis of observations identified critical events and incidents involving probability and uncertainty.

The critical incident method places the data analysis on the context of the event and relates to "mostly straightforward accounts of very commonplace events that occur in routine professional practice which are critical in the rather different sense that they are indicative of underlying trends, motives, and structures" (Tripp, 1993, pp. 24–25). Thus, critical events in the current study were identified based on instances where children faced dilemmas, problems, or situations with more than one possible option and unknown outcomes. Or, as defined by Jones et al. (1999), probability events have more than one outcome as possible.

Once critical events were identified by the researchers, content analysis was applied to organise and elicit meaning from the collected data. The following four stages of: decontextualisation, recontextualisation, categorisation and compilation, according to Bengtsson (2016) were applied. Initially, the researchers familiarised themselves with the raw data and created meaning units labelled with codes, independently from each other. In the recontextualisation stage, the meaning units were re-addressed in relation to the aim of the study; identify how children and practitioners authentically engage with probability in outdoor activities. The categorisation phase occurred when themes and categories were identified by condensing extended meaning units without losing content of the unit. At this stage triangulation of data took place and researchers shared their findings and interpretations. Lastly, the categories were established and summarised. These were compiled into three sub-themes: probabilistic thinking and problem solving; probabilistic thinking and risk and safety; probabilistic thinking; and imaginative play.

3. FINDINGS

Children's narratives and linguistic expressions of probability and uncertainty were video-recorded and transcribed, during their daily outdoor activities. In a total of 142 minutes of naturalistic observations there were nine critical events identified under the context of probability. In employing Bengtsson's (2016) four stages of content analysis there were three emerging themes: probabilistic thinking and problem solving; probabilistic thinking and risk and safety; probabilistic thinking; and imaginative play.

Overall, there were 117 references to probabilistic words such as might, may, shall, guess, what if, could, can. Interestingly, 95% of these words were mentioned initially by the practitioners. In particular, the practitioners made use of these words through 226 open ended questions. Thus, the open-ended questions supported children's thinking and led them to make inferences and find possible answers. Furthermore, these open-ended questions appeared in 77.5% of the practitioner-led structured activities rather than in child-initiated or free play. In most references to probabilistic notions, materials and manipulatives that were visible and accessible were utilised. During the activities the children reasoned subjectively and made strong links between cause and effect. In the following critical event, children were guessing where a noise possibly came from while they were climbing on a wooden plank to board a pirate ship. Some children provided subjective answers (a spider noise) whereas others identified the most likely source of the noise (a crack). For reporting purposes, the practitioners and the children were each assigned an alphanumeric code.

P1: What do you think it was, that snapping noise?
C2: Erm, I … it's the … it, it's the … it was just a, it was just a spider walking on it.
P1: A spider walking on it. Right, well let's put it down and see if we can hear it again, wait a minute cos it's not on properly. Right just one at a time on there, one at a time, that means C2 you need to step off for a minute.
C6: I heard it again (as he walks the plank).
P1: You heard it again, what do you think it was?
C6: A crack!
P1: A crack.
P10: A spider noise!

3.1. PROBABILISTIC THINKING AND PROBLEM SOLVING

Children made inferences when having to solve a problem. They would engage with options or possible solutions to overcome situations underpinned by a problem or a dilemma. When a stimulus occurred, they would try to reach possible conclusions based on evidence and reasoning. The following play episode was a structured activity where each child (C) was invited to make their own stickman. The practitioners (P) provided the materials and guidance to help each child create their own crafts, following the narration of the story earlier in the day. The annotations in the squared brackets show the way the researchers carried out their analysis in identifying critical events of probability and the context in which these occurred.

C6: This one is mine.
P1: That one is yours and what shall we put on it? [problem]
C6: With lots of glue [possible solution].
P1: With lots of glue (…) Where you gonna take him to make him happy? [possible place]
C6: Err, to the family tree [inference].
P1: To the family tree, there's your stickman, go and see if you can find the family tree.

Here the problem-solving situation had to do with the children finding ways of creating their own stickman and setting, based on the resources and space outdoors. C6 sorted out how to join the stickman's eyes with the main body by asking for glue and identified the most possible place for his stickman to be happily in, as the family tree. With the encouragement of the practitioner, C6 took off to find this possible place after making the inference that this is where his stickman would like to be.

In this next child-initiated play episode, children decided to make a Gruffalo cave with materials they found in the outdoor space in front of the nursery. There were six children and two practitioners engaged in the activity, which lasted for around 23 minutes. Children employed their probabilistic thinking when trying to determine how and where to make the cave.

C2: Let's make an extra big cave and … (stretched his arms out wide).
P2: Ooo, C2, just be careful.
C2: Let's build an extra big cave for all of us [problem]
C4: Yeah, yeah.
P2: Where are we putting it then?
C10: Building some ladders

C2: Building it right here (raised vocal tone whilst walking to the left and pointing to a space in the garden) [possible solution 1]
P2: What are we going to lean the sticks on? What are the possibilities?
C2: Ermmm (walks towards fence and points at fence) [possible solution 2]
P2: You're going to lean them against the fence
C1: (nods) Yes.

In this excerpt, children moved their idea of making a cave from being a problem to estimating the possibilities, how to setup the solution, and chose the most viable option. Practitioners were supportive, which enabled the children to find possible ways of deciding where best to locate their cave. The children moved through two possible solutions before deciding where to construct their cave.

3.2. PROBABILISTIC THINKING AND RISK AND SAFETY

Children unraveled their probabilistic reasoning in cases where risk and safety were involved. In these instances, they would think and make links between causes and consequences. In the following play episode, which lasted around 40 minutes, all participants followed a practitioner-led activity where a campfire was lit and each child would have a marshmallow. Children were seated on logs surrounding the campfire space and with the lead of P1 they made observations, estimations, and connections. Probabilistic thinking would be applied when talking about safety around the campfire and when noticing the changes and effects of the fire.

P1: And there's no more cotton wool, so what are we going to do if we've got none left?
C3: Find some, go to the shop and buy more [inference].
C8: Get some more on.
P1: Well, where are we going to get some more from?
C6: Go to the fairy forest [inference]
C3: From the shop, go to the shop and get some (…)
P2: What will the flames do to the marshmallows?
C6: Make them really hot [inference].
P2: Make them really hot, what colour do you think the marshmallows might turn?
C6: Black, black, black (…)
P1: What does it look like when there is two [marshmallows] together?
C6: A big marshmallow [inference].
P1: A big marshmallow. (…)
P1: That's it C3 safely walk back. Ooo, is it nice, try and keep it on the stick or we'll get sticky fingers. Good boy C3, why are you blowing it?
C3: Cos it's hot.
P1: Very hot isn't it, cos the flames have made it nice and warm. Shall we see what happens when we put your sticks on the campfire. Shall we see what happens to this marshmallow?
C5: Yeah.
P1: What do you think is going to happen?
C5: It will get really hot and really (…), put my marshmallow in really deep [inference].
P1: We sink it in don't we and we watch what happens.
C5: It's like a fan [inference].
P1: A fan, spinning.
C6: Yeah
P2: What else does it look like?
C5: A sausage roll [inference].

In this extract we can see children's inferences and guesses made while observing the campfire and marshmallows. They connected the possible causes and effects that underpinned the risk and safety issues and identified the likelihood of events. These are both subjective and objective, spontaneous and scientific, evidence-based and personally based. Furthermore, in this authentic activity, the practitioner played a core role in scaffolding children's reasoning, through posing open-ended questions. Children, in turn, share and extend their thinking when considering and describing possibilities and probabilities.

3.3. PROBABILISTIC THINKING AND IMAGINATIVE PLAY

The children engaged with probabilities while immersed in imaginative play. In the following play episode, children during free play, decided to make a den. After finding some branches, transferring them, and forming a den, they welcomed the provocation of C3 to add a roof. The extract starts with the "guess what 'of C3 and gets extended to last 33.'"

C3: And guess what, I'm giving the sticks to build the roof [provocation]
C7: Watch out!
P2: If you pass me the sticks, shall I put them on?
C8: No, I will.
P2: Go on then.
C7: I will too.
C6: I've got one.
C3: I've got a big stick (…)
C8: More teamwork please, more teamwork (shouting to other children), I need more teamwork!
P1: Wow guys! (…) That's a really good idea to do a roof (…)

During this activity, children's imagination was in flow. Later, they gave another twist to their play sequence. They started talking about alternatives (what if) in case the den got blown away. The children associated their lived experiences with the classic story of the three little pigs and the wolf.

C4: What if the big bad wolf comes and blows all these sticks down? [provocation]
C5: Then we'll have to come outside and build an even stronger house, won't we?
C6: A brick house.
P2: A brick house. Yes, that is a very good idea.

Both provocations noted in this critical event derived from the children. It was one of them that raised the possibilities and probabilities that could relate to the activity of den making. Through social interactions these were then put into practice through hands-on actions (putting sticks on the roof) or linguistically (proposing the option to make a steady house out of bricks). The practitioners were present, but they stepped back, keeping an eye and when needed, facilitated children's play, learning, and thinking.

4. DISCUSSION

In this ethnographic study, children aged 3–4 years-of-age were found to use probabilistic words and thinking while playing outdoors. Through both structured and free-play activities, the young children employed aspects of possibilities, chance, uncertainty, options, and probable outcomes. They articulated possible alternatives mainly in three instances; while attempting to find solutions, through imaginative play, and when confronting risk and safety issues. Hence, children experience, encounter, and express probabilities in their daily routines intuitively. These are enhanced through the support of practitioners' open-ended questions and the use of materials and concrete manipulatives.

This small-scale study confirms that children as young as three have started already to form preconceptions (Batanero et al., 2016), primary intuitions (Fischbein, 1975), spontaneous knowledge (Piaget & Inhelder, 1975), and everyday concepts (Vygotsky, 1962) on probability. When interacting in meaningful playful contexts, children make inferences, guesses, and weigh the odds. In some cases, they attribute subjective justifications and in other cases more scientific estimations. For example, in answering the question, "Where is it (most) probable to find more cotton wool?" the children provided the answer, "Go to the shop and buy more." They also gave a more subjective answer, "G to the fairy forest." Both answers showcase origins of probabilistic reasoning.

The subjective accounts illustrated are common in young children (e.g., Girotto et al., 2016; Nacarato & Grando, 2014; Nikiforidou et al., 2013) and even infants have demonstrated signs of early probability learning while they interpret and associate information from their environments and make inferences (e.g., Denison & Xu, 2014; Kushnir et al., 2010; Waismeyer et al., 2015). Thus, their accounts and intuitions can become the foundations for constructing more advanced probabilistic literacy in the preschool setting onward. Children's previous knowledge and daily exposure to uncertainty can feed into educational activities that promote probability and data reasoning, as advocated for, from early years (Bargagliotti et al., 2020; Leavy et al., 2018; Martinez, & LaLonde, 2020; Nikiforidou, 2018). In this direction, the current study adds to the research base used to determine what children already know and understand before instruction and in turn, how this can inform curriculum design and pedagogy.

In curriculum design in early years, probability content includes probability language, discussions, experimentation, and the use of materials and manipulatives (HodnikČadež & Škrbec, 2011; Nikiforidou, 2019; Threlfall, 2004). Without any instruction, it was found in this ethnographic study that children and practitioners participated in numerous probabilistic occurrences. They used probability language and made speculations and predictions. They wondered and pursued possible and probable answers. During the observations, it was noted that the materials and concrete items also contributed to the contextual framework of probability incidents by provoking, initiating or facilitating the discussion or play activity. For example, in the den making play sequel children used sticks, stones, and other materials found around them. These affordances allow children to extend their play opportunities and possibilities.

Another key element reflected in this study is the language framing probability. Language plays a key role in teaching and learning probabilities (Bargagliotti et al., 2020; Nacarato & Grando, 2014). Specifically, teachers' talk is fundamental in stimulating and extending students' thinking. Questioning strategies may make a difference and open-ended questions tend to sustain the interactions (Creemers & Kyriakides, 2006) and give children the opportunity to expand their ways of thinking (Yang, 2010). Practitioners use open-ended questions to encourage children's "what if" attitude, follow up children's replies, and inspire them to think of possibilities and options mainly in the cases of guided activities. The effectiveness of open-ended questions was evident in the critical events.

From a methodological point of view, this ethnographic study provided in-depth qualitative data on children's consideration of uncertainty and probability during outdoor play. This approach provided holistic accounts (Siraj-Blatchford & Siraj-Blatchford, 2001) and recorded children's own ideas and understandings influenced by their socio-cultural microcosms (Ritchie, 2020), with a focus on how they faced uncertainty when outdoors. This methodology enabled the tracing of children's lived experiences while playing freely or participating in structured activities. The "social actors" (James, 2011)—children and practitioners—were given voice to manifest how they responded to instances of probability when interacting in their natural environment. This non-experimental design allowed data to be authentic, more-than-human (Ingold & Palsson, 2013; Pink, 2015), capturing the role and the relational connection between the mind, body and environment. Thus, elements of probabilistic thinking were identified in relation to participants' language, movements, and the wider situational context.

Children as young as three years-of-age showed signs of probabilistic thinking when facing problems, when engaging in imaginative play, and when exploring aspects of risk and safety. Early experiences, intuitions and preconceptions develop as children grow up and interact with environmental cues, information flow, linguistic expressions, dilemmas, possibilities, and alternatives. Nonetheless, this study is socio-culturally restricted, deeming it unfair to make generalisations. A larger sample, diverse contexts, and numerous play episodes could be considered in further work. Undeniably young children bring to their preschool setting prior knowledge and understandings of probability. These life experiences, subsequently, can become the steppingstone for more advanced scientific concept formation. Therefore, more research is needed to shed light on how young children can be and become statistically literate citizens of the present and future.

ACKNOWLEDGEMENTS

We thank the children and practitioners for participating in the study.

REFERENCES

Bargagliotti, A., Franklin, C., Arnold, P., Gould, R., Johnson, S., Perez, L., & Spangler, D. (2020). *Pre-K–12 Guidelines for Assessment and Instruction in Statistics Education (GAISE) report II*. American Statistical Association and National Council of Teachers of Mathematics.

Batanero C., Chernoff E. J., Engel J., Lee H. S., Sánchez, E. (2016). Research on teaching and learning probability. *Research on teaching and learning probability: ICME-13 Topical Surveys*. Springer.

Bengtsson, M. (2016). How to plan and perform a qualitative study using content analysis. *Nursing Plus Open 2*, 8–14.

Creemers, B. P. M., & Kyriakides, L. (2006). Critical analysis of the current approaches to modelling educational effectiveness: The importance of establishing a dynamic model. *School Effectiveness and School Improvement*, *17*(3), 347–366. https://doi.org/10.1080/09243450600697242

Denison, S., & Xu, F. (2014). The origins of probabilistic inference in human infants. *Cognition 130*(3), 335–347.

Fischbein, E. (1975). *The intuitive sources of probabilistic thinking in children*. Reidel Publications.

Fischbein, E. (1987). *Intuition in science and mathematics: An educational approach.* Reidel Publications.

Girotto, V., Fontanari, L., Gonzalez, M., Vallortigara, G., & Blaye, A. (2016). Young children do not succeed in choice tasks that imply evaluating chances. *Cognition*, *152*, 32–39. http://dx.doi.org/10.1016/j.cognition.2016.03.010

Greer, B. (2001). Understanding probabilistic thinking: The legacy of Efraim Fischbein. *Educational Studies in Mathematics*, *45*, 15–33. https://doi.org/10.1023/A:1013801623755

Groth, R. E., Austin, J. W., Naumann, M., & Rickards, M. (2021). Toward a theoretical structure to characterize early probabilistic thinking. *Mathematics Education Research Journal 33*, 241–261. https://doi.org/10.1007/s13394-019-00287-w

Hammersley, M., & Atkinson, P. (2007). *Ethnography: Principles in practice* (3rd ed.). Routledge.

Hawkins, A., & Kapadia, R. (1984). Children's conceptions of probability: A psychological and pedagogical review. *Educational Studies in Mathematics*, *15*, 349–377.

HodnikČadež, T., & Škrbec, M. (2011). Probability of pre-school and early school children. *Eurasia Journal of Mathematics, Science & Technology Education*, *7*(4), 263–279.

Ingold, T., & Palsson, G. (Eds.), (2013). *Biosocial becomings: Integrating social and biological anthropology*. Cambridge University Press.

James, A. (2011). Ethnography in the study of children and childhood. In P. Atkinson, A. Coffey, S. Delamont, J. Lofland & L. Lofland (Eds.), *Handbook of ethnography* (pp. 1–22). SAGE Publications.

Jones, G. A., Langrall, C. W., Mogill, A. T., & Thornton, C. A. (1999). Students' probabilistic thinking in instruction. *Journal for Research in Mathematics Education*, *30*(5), 487–519.

Kingston, M., & Twohill, A. (2022). Young children's use of subjective thinking in response to probabilistic tasks. *Statistics Education Research Journal, 21*(3), Article 5. https://doi.org/10.52041/serj.v21i3.8

Kushnir, T., Wellman, H. M., & Xu, F. (2010). Young children use statistical sampling to infer the preferences of other people. *Psychological Science 21*, 1134–1140. https://doi:10.1177/0956797610376652

Leavy A., Meletiou-Mavrotheris M., Paparistodemou E. (2018). Preface. In A. Leavy, M. Meletiou-Mavrotheris & E. Paparistodemou (Eds.), *Statistics in early childhood and primary education: Early mathematics learning and development* (pp. ix–xxii). Springer.

Martinez, W., & LaLonde, D. (2020). Data science for everyone starts in kindergarten: Strategies and initiatives from the American Statistical Association. *Harvard Data Science Review, 2*(3). https://doi.org/10.1162/99608f92.7a9f2f4d

Nacarato, A. M., & Grando, R. C. (2014). The role of language in building probabilistic thinking. *Statistics Education Research Journal*, *13*(2), 93–103. https://doi.org/10.52041/serj.v13i2.283

Nikiforidou, Z. (2018). Probabilistic thinking and young children: Theory and pedagogy. In A. Leavy, M. Meletiou-Mavrotheris & E. Paparistodemou (Eds.), *Statistics in early childhood and primary education: Early mathematics learning and development* (pp. 21–34). Springer.

Nikiforidou, Z. (2019). Probabilities and preschoolers: Do tangible vs virtual manipulatives, sample space and repetition matter? *Early Childhood Education Journal 47*, 769–777. https://doi.0.1007/s10643-019-00964-2

Nikiforidou, Z., Chadjipadelis, T., & Pange, J. (2013). Intuitive and informal knowledge in preschoolers' development of probabilistic thinking. *International Journal of Early Childhood, 45*(3), 347–357. https://doi:10.1007/s13158-013-0081-6.

Piaget, J., & Inhelder B. (1975). *The origin of the idea of chance in children*. Norton.
Pink, S. (2015). *Doing sensory ethnography* (2nd edition). SAGE Publications.
Ritchie, J. (2020). Ethnography in early childhood education. In G. W. Noblit (Ed.), *The Oxford encyclopedia of qualitative research methods in education.* (pp. 1–19). Oxford University Press.
Siraj-Blatchford, I., & Siraj-Blatchford, J. (2001). An ethnographic approach to researching young children's learning. In G. Mac Naughton, S. A. Rolfe, & I. Siraj-Blatchford (Eds.), *Doing early childhood research: International perspectives on theory and practice* (pp. 193–207). Allen & Unwin.
Threlfall, J. (2004). Uncertainty in mathematics teaching: The National Curriculum experiment in teaching probability to primary pupils. *Cambridge Journal of Education 34*(3), 297–314.
Tripp, D. (1993). *Critical incidents in teaching: Developing professional judgement.* Routledge.
Vygotsky, L. (1962). *Thought and language.* (E. Hanfmann & G. Vakar, Eds.). MIT Press.
Waismeyer, A., Gopnik, A. & Meltzoff, A. N. (2015). Causal learning from probabilistic events in 24-montholds: An action measure. *Developmental Science 18,* 175–182. https://doi:10.1111/desc.12208
Wolcott, H. F. (2008). *Ethnography. A way of seeing* (2nd ed.). Altamira.
Yang, C. C. R. (2010). Teacher questions in second language classrooms: An investigation of three cases. *Asian EFL Journal 12*(1), 181–201. https://doi:10.1017/cbo9781139524469.005

ZOI NIKIFORIDOU
4th km. Ioannina-Athens National Highway
45110, Ioannina
Greece