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**MEASURE WITH PLEASURE: LENGTH MEASUREMENT
TEACHING FRAMEWORK IN EARLY CHILDHOOD**

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Abstract

Length measurement is considered to be an important area of mathematics as it is used consistently in our everyday lives. It develops mathematical thinking, reasoning and logic. Mathematics in early childhood includes two main domains: geometry and number, length measurement connects these two together. That being said, measuring is a complex skill that includes what may be foundational concepts, such as: conservation, transitivity, iteration of a standard unit, understanding of the attribute, equal partitioning, accumulation of distance, origin, and relation to a number. Literature indicates that sadly, many children are not able to acquire the basic measurement skills or use them properly. They measure in a faulty manner, do not apply it correctly in relevant situations and have difficulties in explaining measurement procedures. Measurements in early childhood must be done in a procedural manner within authentic situations in order to be relevant to children's lives. In order for children to learn measurements in a significant fashion, they need to be active participants in structured yet authentic games. In this paper, several activities that demonstrate a cognitively appropriate instruction of length measurements for early childhood educational settings will be introduced.

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1. Introduction

This article is about developing length measurement skills in early childhood. One has to think about how children's spatial sense can be advanced, by activities that begin with play and include key concepts of measurement. In different sciences different values are measured, and to give phenomena an objective character, different units of measure are used. The history of mathematics in general and the history of geometry in particular started from the measurements. The word itself "geometry" means "soil measurement" in Greek: soil = geo, measurement = metro (Nitabach & Lehrer, 1996). In fact, it is necessary to measure any physical quantity and therefore choose appropriate units of measurement, which are fixed and known quantities for each physical quantity: weight, temperature, velocity, volume, angle and more. Typically, for measuring any physical quantity there are several units of measurement. In ancient cultures, the most accessible sizes were used as units of measurement - parts of the human body, such as cubit or tap, or sizes related to the human body, such as a step. Measurement units such as where to measure volume are also known. When you measure something, you actually define its properties in relation to special units of measure. For centuries, humans have developed methods of measurement that are common in most parts of the world (Morris & Langari, 2012).

Humans, however, use units of measure routinely in their lives, but it should not be forgotten that defining these units is a complex and difficult task, sometimes requiring complicated technological solutions in order to represent the unit accurately and consistently (Clements & Sarama, 2014). Whereas in the past the units of measurement were determined out of social agreement on a certain size that was available to all those involved in the measurement, today the goal is to link the units of measurement to natural, independent phenomena that exist in nature.

1.1. Measurement in early childhood

It is commonly known that the understanding of measurement is already being developed in early childhood i.e in the preschool years. Children in preschool are aware of the continuous attributes such as mass and length but they cannot measure or quantify them accurately. Children in preschool have been found to struggle with reliable judgement about which amounts of water, or clay for example is more. Children know that if they have a little amount of water and they are given more, the overall amount is bigger because they use perceptual clues. However, towards the age of 5 years old, children can overcome the use of perceptual clues and use reasoning about measuring quantities.

Seo and Ginsburg (2004) claim that children in early childhood encounter quantities and discuss it. At the beginning they learn how to use words that present the quantity or magnitude of attributes. Afterwards they learn how to compare between two objects directly. And then they recognize equality or inequality (Boulton-Lewis et al., 1996) which advances them towards measurement. This will be examined in detail in the case of length.

1.2. Length measurement

As a preliminary definition, it can be said that length is a characteristic of an object that may be given a numeric value, by quantifying between two endpoints of such an object. Distance is being referred to as the empty space between two points. Learning about length and measuring length and distance is more complex than that. Measuring consists of two aspects: one is the identification of the measure and the second is subdividing something by that unit and placing that unit by the object (end to end). The identification and subdivision are two hard and complicated activities that are often not taken into consideration in the traditional curriculum (Clements & Stephan, 2004; Clements & Sarama, 2014; Dooley et al., 2014).

In this article a discussion regarding length will be presented in the next two sections. The first section will present several key concepts that underlie the base of a measurement. The second section will present research-based teaching methods that help children develop skills and concepts in length measurement.

1.3. Concepts in linear measurement

Some important concepts underlie children's learning about length measurement, these concepts can be used, as seen in Table 1, to understand how children think about space as they go through the physical exercise of measurement (Clements, 1999; Lehrer et al., 2003).

Table 1. Central concepts in linear measurement

	Idea	Description
Conceptions of unit	Iteration	A subdivision of a length is translated to obtain a measure.
	Identical unit	Each subdivision is identical.
	Tiling	Units fill the space.
	Partition	Units can be partitioned.
	Additivity	Measures are additive, so that a measure of 10 units can be thought of as a composition of 8 and 2, and so on.
Conceptions of scale	Zero-point	Any point can serve as the origin or zero-point on the scale.
	Precision	The choice of units in relation to the object determines the relative precision of the measure. All measurements are inherently approximate.

It is agreed that the ideas presented form the base of measurement and should be taken into account in the teaching of measurement of any kind (Boulton-Lewis et al., 1996; Clements & Sarama, 2000, 2011; Kamii, 2006). With these ideas in mind during teaching, kindergarten teachers will be able to better interpret children's understanding and ask them leading questions to help them build these ideas themselves. As said, traditional teaching does not advance the building of these ideas or perceptions among children and therefore the question of "what are the activities that can build these ideas?" should be asked.

2. Problem Statement

The concept of length is critical in its importance both in everyday life and in formal geometry. In everyday life, one uses length to describe the size of objects or the distance he has reached. In geometry, humans use length to add accuracy to descriptions of shapes and bodies (Battista, 2006). Despite its importance and although it seems simple, the concept of length can be very difficult to understand for children. The critical question is how do children develop a concept of length?

2.1. Length concept and its measurement

The curriculum in mathematics in different ages, allocates a significant place to the learning of measurement in general and length measurement as part of it. In Spite of the repetitive learning in different ages, in the kindergarten and elementary school, researches show that there is only little understanding of the measurement principles, for example, many children do not know what is a length unit, what is the measured length if you use a subdivided repetitive unit and what are the rules to use subdivided repetitive measurement units (). These difficulties are explained by a non suitable teaching that does not allow meaningful experiment. Usually there is a request to measure different objects, at times with a very simple direct comparison or measurement using mediators, and the given answer is a numeric answer. The children do not take part in the research, the comparison and the logical understanding of the measurement process ().

Length measurement is a part of the kindergarten mathematics curriculum, because these skills can be taught and developed in this age unlike measurement of other sizes, such as: area, volume or weight, and that is because length measurement is based on a linear measurement.

Many researchers (Clements & Stephan 2004; Clements & Sarama 2014; Nunes et al., 1993; Sarama et al., 2011) support the use of versatile means that allow measurement using a mediator, which makes the measurement easier and contributes to the development of early abilities and the building of new knowledge.

2.2. Direct and indirect comparison of length

In the first stages of skills acquiring in the measurement of length, children use direct comparison. Direct comparison is a comparison in which two objects are compared with a joint measurable size (length, weight etc.) without using a mediator. In this case children decide if the measured objects are even, while examining if there is a joint beginning and end points.

In the next developmental stage, children measure using a mediator. They are essentially comparing two objects using a third object (like a string or a stick). Usually, the comparison with a mediator is done in the following manner: one of the objects is compared to a mediator, and then the mediator is compared to the other object and conclusions are conducted in accordance to that. In later developmental stages a measurement unit is used in a way which examines how many times the measurement unit is “covering” the measured object. In that way a numeric answer regarding the size of

the object is given and it depends on the size of the unit that is being used like: foot, fist, cube etc. (Zacharos & Kassara, 2012).

This learning is challenging and occurs over many years. Here is the place to describe and mention just a few common misconceptions and difficulties that children have, which were tried to deal with through activities tailored to preschool children (Clements & Sarama 2014).

- Children can compare between two objects only at one of their ends, in order to determine which of the two objects is longer.
- At times children create spaces between the measurement units or create an overlap between the units during the measurement.
- Some children believe it is necessary to have many copies of a unit to “fill up” the length of the object and will not iterate one copy of a unit (laying it down, marking where it ends, moving it, and so on).
- Some children will “fill up” the length of the object with a unit such as a ruler but will not extend the unit past the endpoint of the object they are measuring. Therefore, they always leave out any fractional part of the unit.
- Children do not understand that the units need to be in even sizes, in order to give a numeric answer.
- Children may incorporate units in different sizes, and give a numeric answer that incorporates the sum of the units in which they used.

3. Research Questions

Children naturally measure almost anything. Early and repetitive experiences with cultural tools such as rulers, and with a general epistemology of quantification that characterise many contemporary societies, provide fertile ground for developing a mathematical understanding of measurement. Developmental studies suggest that children's perceptions of measurement reflect a collection of evolving concepts whose coordination gradually develops as a network of relationships rather than as a unified concept of measurement. This article seeks to promote children's spatial understanding, through activities that begin with play and include key concepts of measurement.

4. Purpose of the Study

The importance of this article lies in the fact that it brings to the forefront the uniqueness of early childhood learning and the appropriate stages of measurement at this age accompanied by proactive activities. It is important to note again that traditional teaching refers to measurement as an empirical procedure only and not necessarily as a process that requires reasoning / justification.

5. Research Methods

This is a theoretical article based on the research literature that discusses the unique ways of preschoolers to measure length. This is the place to note that various curricula (Ministry of Education,

2010; NCTM, 1989) suggest that the subject of measurement in kindergartens of primary school will include concrete experiences, in which students will use measurement processes, to interact with their environment, and actively explore the real world. Children should be able to control the choice of the appropriate size and type of units of measure for given measurement situations (NCTM, 2000). These requirements are important in elementary school but are doubly important in planning activities for kindergarten children.

6. Findings

Based on the literature review that presented the complexity of acquiring the skills required to measure length, it's time to shed light on the unique early childhood learning path and offer several activities that advance the acquisition of ability.

People, at any age, actively build mathematical knowledge, but children in preschool are a special group, and their teaching should be planned carefully. Clements (2001) points out two of their special features. First, the ideas that preschoolers develop can be quite different from those of adults. Kindergarten teachers should be especially careful not to assume that children "see" situations, problems or solutions, like adults.

Second, young children do not perceive their world or act within it as if it is divided into different professions. Well-planned educational practice helps children develop pre-mathematical knowledge and mathematical knowledge throughout the day. Activities that simultaneously promote intellectual, social, emotional, and physical development should be planned. Such comprehensive teaching and learning builds on the high motivation of kindergarten children to learn through self-direction. Such teaching advances looking at mathematics positively as a problem-solving, self-motivated, and self-directed activity at a time when children are first developing beliefs, habits, and emotions about mathematics (Clements, 2001).

A child's skill advancement in the mathematics field is related to the opportunities he has to deal with mathematics, the way the kindergarten teacher exposes him to dealing with mathematics, the type of activities and the assignments she presents to him, her ability to track his advancement, and the mediation she performs in order to advance him.

Dealing with mathematics in kindergarten should be both occasional and planned. During the activity in the kindergarten the children and the teacher encounter different occasional situations, that involve mathematics or that have the option to deal with mathematics. It is important that the teacher would use this situation and navigate it so that it advances the kids. Using occasional situations to deal with mathematics is important but not sufficient. Occasional situations do not allow dealing with all of the mathematical subjects, and not always allow dealing in a gradual manner, therefore they constitute only some of the intentional mathematical activities in a kindergarten. In parallel the teacher must plan activities in advance and to involve the children in these activities.

A unique project was performed in one of the famous kindergartens in Emilia Reggio in Italy. Clements (2001) describes the project "Shoe and Meter" from the writings of Malaguzzi (1997) in which a group of children wants another desk identical to one they already have. A local carpenter says he will build the table, but he needs measurements, the children first try to measure with their fingers. They then

try to measure with the help of heads, fists, width of arms, and legs. After that the children turn to objects, like books. They seem to be beginning to realise that using objects will be easier than using body parts.

Finally, after working on other measurement tasks suggested by the kindergarteners, the children are present to know that they need some kind of measurable measurement. They start by creating their own rulers. They use a shoe, stepping with it on a strip of paper they put on the table to mark the distances.

What height ...: In the kindergarten garden, the children compare the height of two plants that grew next to each other (the same type in the same flower bed, or between plants in adjacent beds), and use a direct comparison or comparison with a mediator such as a pole on which the height of the plant will be marked (Ministry of Education, 2010).

Throwing and measuring: (1) The children throw a ball from a common starting point. Each child in his turn measures the distance from the starting point to where the ball reached. (2) The children throw a ball from a common starting point to a defined goal and measure the distance between the ball and the goal. This game encourages the use of repeat units, standard or non-standard. It is suitable for children who feel confident in using a direct comparison (Ministry of Education, 2010).

The story of the "rabbitail" (A rabbit with a tail – Figure 1): It is possible to tell the story of the "King of the Tails" by Ronit Hacham-Herson (1987). The story tells about rabbits living in the woods and every year hold a contest among them. The rabbits sit together in the forest and measure their tails. Whoever has the longest tail is chosen to be the king, the tails sit together in the clearing and measure the tails. How to measure? Where do you start? The story is about measuring length, and through it the children learn to know different ways of measuring, among them measuring using measuring tools.



Figure 1. The story of the "rabbitail", a rabbit with a tail

Shoe box game: Inside a shoe box with openings for arms at each end, let's say wooden sticks of different lengths. Each child pulls one stick out of the box. The children compare the lengths of the sticks by placing them on the table surface. The child holding the longer stick, or the shorter one, receives both sticks. If the sticks have the same length, they are returned to the box. This game develops the use of a baseline to compare the length of two objects (Schwartz, 1995).

7. Conclusion

Acceptable units of measure allow us to speak in a common language in almost every area of our lives. Through measurements we give quantitative meaning to the environment in which we live. When we measure, we use mathematical skills. Children engage in measurements and the perception of different quantities and the order of scale even before they develop an understanding and measurement skills. As children acquire more and more mathematical concepts, they also develop an understanding of size ratios, using thinking skills such as sorting, comparing, estimating, problem solving, distinguishing and generalising. The most significant contexts for developing comprehension and measurement ability in preschool occur when children engage in measurement in real-life situations that require measurement. In planning the teaching and learning processes in the kindergarten, the kindergarten teacher must combine the subject of measurement with the various topics included in the curriculum in the kindergarten.

In conclusion, this article paves the way for future research aimed at examining the use of strategies and measuring devices among compulsory kindergarten children through play in performing a variety of tasks related to measuring length. A variety of materials that allow measurement will be offered, the children will be asked to explain their measurement procedures.

References

- Battista, M. T. (2006). Understanding the development of students' thinking about length. *Teaching Children Mathematics*, 13(3), 140- 146.
- Boulton-Lewis, G. M. (1987). Recent cognitive theories applied to sequential length measuring knowledge in young children. *British Journal of Educational Psychology*, 57, 330-342.
- Boulton-Lewis, G. M., Wilss, L. A., & Mutch, S. L. (1996). An Analysis of young children's strategies and use of devices for length measurement. *Journal of Mathematical Behavior*, 15(3), 329-347.
- Clements, D. H. (1999). Teaching length measurement: Research challenges. *School Science and Mathematics*, 99(1), 5-11.
- Clements, D. H. (2001). Mathematics in the preschool. *Teaching Children Mathematics*, 7(5), 270-275.
- Clements, D. H., & Sarama, J. (2000). The earliest geometry. *Teaching Children Mathematics*, 7(2), 82-86.
- Clements, D. H., & Sarama, J. (2011). Early childhood mathematics intervention. *Science*, 333, 968-970.
- Clements, D. H., & Sarama, J. (2014). *Learning and teaching early math: The learning trajectories approach*. Routledge.
- Clements, D. H., & Stephan, M. (2004). Measurement in Pre-K to Grade 2 mathematics. In D. H. Clements, J. Sarama, & A. M. DiBiase (Eds.), *Engaging young children in mathematics: Standards for early childhood mathematics education*, 299 – 317. Lawrence Erlbaum Associates.
- Dooley, T., Dunphy, E., Shiel, G., O'Connor, M., & Travers, J. (2014). *Mathematics in early childhood and primary education (3-8 years)*. *Teaching and learning*, 18.
- Hacham-Herson, R. (1987). *The king of tails or who has the longest tail*. Ramat Aviv, Tel Aviv: The Center for Educational Technology. [Hebrew]
- Kamii, C. (2006). Measurement of length: How can we teach it better? *Teaching Children Mathematics*, 13(3), 154-158.
- Kamii, C., & Clark, B. F. (1997). Measurement of length: The Need for a better approach to teaching. *School Science and Mathematics*, 97(3), 116-121.
- Lehrer, R., Jaslow, L., & Curtis, C. (2003). Developing an understanding of measurement in the elementary grades. In D. H. Clements & G. Bright (Eds.), *Learning and teaching measurement:*

- 2003 yearbook of the National Council of Teachers of Mathematics (pp. 100–121). Reston, VA: NCTM.
- Malaguzzi, L. (1997). *Shoe and meter*. Reggio Emilia, Italy: Reggio Children.
- Ministry of Education. (2010). *Israel National Mathematics Preschool Curriculum*.
- Morris, A. S., & Langari, R. (2012). *Measurement and instrumentation: theory and application*. Academic Press.
- National Council of Teachers of Mathematics. (1989). *The Curriculum and Evaluation Standards for School Mathematics*. Reston, Va.: NCTM.
- National Council of Teachers of Mathematics. (2000). *Principles and Standards for School Mathematics*. Reston, Va.: NCTM.
- Nitabach, E., & Lehrer, R. (1996). Developing spatial sense through area measurement. *Teaching Children Mathematics*, 2(8), 473-476.
- Nunes, T., Light, P., & Mason, J. (1993). Tools for thought: The measurement of length and area. *Learning and instruction*, 3(1), 39-54.
http://meyda.education.gov.il/files/Mazkirut_Pedagogit/Matematika/TochnitKdamYesodiHeb.pdf
- Sarama, J., Clements, D. H., Barrett, J., Van Dine, D. W., & McDonel, J. S. (2011). Evaluation of a learning trajectory for length in the early years. *ZDM*, 43(5), 667.
- Schwartz, S. L. (1995). Developing power in linear measurement. *Teaching Children Mathematics*, 1(7), 412-416.
- Seo, K. H., & Ginsburg, H. P. (2004). What is developmentally appropriate in early childhood mathematics education? Lessons from new research. In D. H. Clements, J. Sarama, & A. M. DiBiase (Eds.), *Engaging young children in mathematics: Standards for early childhood mathematics education*, 91-104. Mahwah, NJ: Lawrence Erlbaum Associates.
- Zacharos, K., & Kassara, G. (2012). The development of practices for measuring length in preschool education. *Skholé*, 17, 97 – 103.
- Zacharos, K., Antonopoulos, K., & Ravanis, K. (2011). Activities in mathematics education and teaching interactions. The construction of the measurement of capacity in preschoolers. *European Early Childhood Education Research Journal*, 19(4), 451-468.