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Children Explain Their Reasoning About Measurement: "Because It's Big and Heavy!"

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Abstract
Measurement concepts taught in preschools generally include length, size, weight, time, temperature, sometimes volume and area. There are several ways to examine children's concepts and reasoning skills about measurement. One of them wants children to explain their decisions they make solving measurement problems. This study aimed to determine the reasoning skills of children in the area of measurement. The study group is composed of randomly selected 204 children between 60 and 74 months attending preschools. Data were collected using Early Mathematical Reasoning Skills Assessment Tool. Results showed that no significant difference was found between the scores of reasoning of boys and girls. Measurement reasoning scores of older children are higher than younger children.
Keywords: Measurement, Reasoning, Preschool, Math, Rubric.

1. Introduction

Measurement is important in terms of applying mathematics or establishing a relation between mathematics and non-mathematical fields such as social sciences and art, as well as being important in terms of learning the students' learning levels (Umay, 2007). Measurement is also an important heading in terms of science education and especially scientific process skills (Kuhn, 2016; Gerde, Schachter, and Wasik, 2013; Kirch, 2007). Measurement seen as an early STEM skill (Schroeder and Kirkorian, 2016; Aladé, Lauricella, Beaudoin-Ryan and Wartella, 2016).

The measurement heading is included within the mathematical area content standards determined by NCTM (2013). There is a content that explains how numerical values can be given by the properties of objects within this standard. Furthermore, the skills of solving area and volume problems are also essential (Latterel, 2011).

Conservation and transitivity are two important concepts as necessary for understanding of measurement. These are also related to comparison. Montague-Smith and Price (2012) stated that measurement can not be done without making a comparison and the measurement is actually about making comparisons. According to Van de Walle, Karp and Bay-Williams (2014), measurement shows the number obtained as a result of comparing the property of an object (situation/incident) with a unit that has the same property. In the preschool period, children need much experience regarding non-standard length, weight and capacity units. Standard units can be effectively presented after the concept of measurement is well developed.

Kindergarteners begin formal measurement experiences by determining the lengths, weights, and other measurable attributes of objects using nonstandard measures (e.g.: pencils, erasers, hands, feet, etc.). They also learn to compare and describe differences between two objects in terms of a common measurable attribute. In comparing, they begin to use terms such as *shorter* and *taller, more of* and *less of*, *longer* and *shorter*, *light* and *heavy,* etc. All explorations take place in the context of hands-on experiences involving everyday, real, and other concrete objects (Rivera, 2014). Structured block play (Verdine, Golinkoff, Hirsh‐Pasek, Newcombe, Filipowicz, and Chang, 2014) and children's literature (Tucker, Boggan and Harper, 2010; van den Heuvel-Panhuizen, van den Boogaard and Doig, 2009) is also important to develop skills in measurement.

In the study carried out by MacDonald (2010a), the experiences of children with measurements while starting the school in the pre-school period and in the non-school environments, and how they obtain these experiences were investigated. It was revealed that children show most of the measurement skills even before they start school and without receiving any formal training on measurements. Furthermore, children were able to use a suitable language for length measures by using both paired (i.e. "short" and "tall") and comparative ("longer than" and "shorter than") words.

Of all attributes, length can be considered as the most elementary one. Before entering school, children have already developed some knowledge of measurement through playful activities. In kindergarten, the teaching builds on this informal knowledge and offers children meaningful situations in which they can extend their understanding of length measurement (Van den Heuvel-Panhuizen and Elia, 2011).

McDonough and Sullivan (2011) drew attention to the importance of using non-standard units (span, bar, etc.) while making measurements of length. Teaching in such a way that builds a link between counting the units and using standard units allows teachers and students to focus on reasoning rather than just counting. It was put forth that there is a direct but insufficient relationship between the counting skill and the ability to measure length using non-standard units. The correct use of non-standard units requires the understanding of unit repetition and the requirement that there should be no gap or skipping between the units, as well as the correct counting of units.

In a research it is investigated the effects of different pedagogical approaches on the learning of length measurement in kindergarten children. Neither guided instruction nor center-based approaches influenced learning more so than free exploration. Older children did better on the measurement tasks which suggest that age or a developmental progression, rather than the pedagogical approach, is more influential when learning how to measure (Kotsopoulos, Makosz, Zambrzycka and McCarthy, 2015).

Lee's work (2012) focused on children as young as 12 months to three years there was evidence in unstructured outdoor play of experimentation with ideas of measurement, including children attempting to lift or move heavy objects. MacDonald (2010b) found that children of four to six years old have an awareness of the attribute of mass, as revealed in drawings of measurement situations. Cheeseman, McDonough and Clarke (2011) argue that, rich experiences involving measuring mass are needed. Their findings point to the value of children having hands on experiences with mass measurement situations. Also they suggest the importance of teachers assessing children's understandings of mass measurement and structuring learning opportunities to build on and extend those understandings.

The initial focus on spatial measurement (length, area, and volume) involves the coordination of two dimensions of students' experience-continuous space and discrete number. Area measurement represents an important transition in the teaching and learning of measurement more generally. Area measure also frequently arises in everyday activity and plays a foundational role in more advanced mathematics. Children's understanding of area develops later than that of length (Smith III, Males and Gonulates, 2016; Montague-Smith and Price, 2012).

More complex measures such as area and speed aren't generally seen as essential elements of a curriculum for young children. They are, however, measures which crop up in conversation and which some children will have heard talked about – even if not in precise terms. Once again, those things which are important within the child's family and broader culture will be most readily learnt (Pound, 2006).

There are two concepts that are much different from one another related to the time that children will use and during which they will learn to measure. The first one is the time at which an incident takes place, i.e., the time recorded. The second one is the period between two events, the concept of the time interval. While teaching the subject of time to children, the most important activity is to talk to them with the aim of developing the extensive vocabulary and language patterns. Teachers of small children should pay attention to the differences of these concepts (Haylock and Cockburn, 2013). Time-related concepts such as before, after, today and minute emerge early in children's language production. Several studies suggest that by age 4 or 5, children can use spatial scales to differentiate the times of events (Hudson and Mayhew, 2011; Busby Grant and Suddendorf, 2009).

It is observed that children only perform activities such as counting, memorizing the names of shapes and writing numbers within the scope of mathematics as a result of both unfavorable environmental conditions and incorrect educational practices. The failure to perform sufficient activities and assessment in the field of measurement may cause delays in children's acquisition of higher skills. As a result of the measurement activities applied without the use of actual materials, the presence of children, who aren't aware of what they are doing, assumed to have learnt various concepts such as shape and number, but can in no way make reasoning, is a quite upsetting but expected situation. Measurement skills that may be required throughout one's life and at every moment of daily life may only become permanent by children's transmitting the knowledge in their mind to their hands.

2. Method

This research was performed in order to examine the reasoning skills of children in the field of measurement. The effect of the gender and age variables on the mentioned skills was investigated.

2.1 Study Group

The study group consisted of 204 children, between 60 and 74 months showing typical development, who were randomly selected from preschools in Ankara province central districts. 44.1% of the children are in the range of 60-65 months, while 55.9% are in the range of 66-74 months. 51% of children were male.

2.2 Data Collection Tool

The data were obtained by using the questions in the measurement section of the Early Mathematical Reasoning Skills Assessment Tool developed by the researcher. Children's information about gender and age- classified as two groups, 60-65 and 66-74 month-olds- were collected from school records.

There are 21 questions in the measurement section of the assessment tool. These questions were examined by domain experts working in the field of mathematics and preschool teaching and selected from the pool of questions. The questions and their visuals were put into their final forms with the pilot study carried out by the researcher. The literature review, expert opinions and pilot application data were taken into consideration when distributing the measurement questions by their fields. The measurement fields and the number of questions are as follows: length (four), weight (five), area (four), time (five) and volume (three).

This tool is a task-based rubric. Rubric is a performance-based assessment that is type of authentic and alternative assessment. Merritt (2015) states that, alternative assessment measures such as rubric, include open-ended exercises, extended-response exercises, and extended tasks.

2.2.1 . Rubric-Criteria for the evaluation of answers

The answers given by the children and the criteria for the evaluation of these answers are given in the following table.

Table 1. The answers and the criteria's for the evaluation of these answers

Response	Score	Criteria
Correct	5	Child provided a full comparative explanation and used both of the concept pairs such as: long-short or big-small, heavy-light, large-narrow, more-less, little-more/much, thin-thick, fast-slow.
	4	Child provided an incomplete explanation and used just one of the concept pairs such as: long-short or big-small, heavy-light, large-narrow, more-less, little-more/much, thin-thick, fast-slow.
	3	Child didn't explain at all or provided an unrelated explanation. Eg. "*I don't know, I order it like this, it's better like this, it was too easy, my mom told me, I am a clever child, I got it*". Just pointed/followed/counted with finger.
Wrong	2	Child knows a little about the concepts/has conceptual confusion/misuses the concept.
	1	Child didn't provide any explanation or the explanation was incorrect. Eg. "*The colors are beautiful, I wanted to do like this*".
No response	0	Child didn't pay any interest at all. Child just played with materials. Child took the materials, but didn't make a comment.

Unlike most other forms of assessment, performance-based assessments do not have only one right answer. Instead, there are levels of proficiency which may be attained by students, which means instructors need an instrument that will allow them to rate each student's performance. This can most easily be accomplished by using a rubric (Myers, 2015). As Dawson (2015) mentions, one rubric may use generic quality words (e.g. 'good' or 'below standard'), whereas another may explain in detail what quality looks like. In this evaluation tool, for each question, the children's comments were evaluated according to the criteria and scored between 0 and 5.

2.3 Data Collection

First of all, permission was taken from Ministry of National Education for the study. The scope of the study was explained to school directors. Group teachers were met and their permission was taken with the guidance of the school directors who supported the study. Time was spent in children's classes before the application to provide an opportunity for them to get used to the researcher.

Children were tested individually in a quiet room in their preschool. The experimenter sat beside the child and put the assessment tool on a table in front of the child. Children were told that they were going to look at some pictures and that the experimenter would ask them questions about the pictures. After child answered, "why did you think like this?" question asked. The experimenter recorded children's responses without giving a clue.

2.4 Data Analysis

Answering percentages and averages were examined. Comparisons were made with the Mann Whitney U test to examine the effects of gender and age variables on the performance of children.

3. Results

The answers given by the children to the questions and the findings obtained as a result of the data analyses related to the variables affecting these reasoning skills are presented.

3.1 Answering percentages

The percentages of knowing the answers given to the questions by the answer criteria in the graded scoring key used in the study were examined. Table 1 shows the averages, frequencies and percentages of questions.

Table 2. Averages, frequencies and percentages of questions

Asking order	Question	Average	Criteria 5 f	5 %	4 f	4 %	3 f	3 %	2 f	2 %	1 f	1 %	0 f	0 %
1	Length 1	3.90	113	**55.4**	32	15.7	27	13.2	-	-	22	10.8	10	4.9
2	Length 2	4.10	86	**42.2**	60	29.4	54	26.5	1	0.5	3	1.4	-	-
3	Length 3	**1.38**	18	8.8	-	-	3	1.5	-	-	183	**89.7**	-	-
4	Length 4	**1.46**	22	10.8	2	1.0	-	-	-	-	180	**88.2**	-	-
5	Weight 1	4.06	61	29.9	110	53.9	25	12.3	-	-	8	3.9	-	-
6	Weight 2	4.24	96	**47.1**	74	36.3	27	13.2	1	0.5	6	2.9	-	-
7	Weight 3	3.95	109	**53.4**	44	21.6	15	7.4	3	1.5	33	16.1	-	-
8	Weight 4	1.98	41	20.1	8	3.9	3	1.5	6	2.9	146	**71.6**	-	-
9	Weight 5	3.57	39	19.1	115	56.4	12	5.9	-	-	38	18.6	-	-
10	Area 1	**4.31**	112	**54.9**	64	31.4	15	7.4	6	2.9	6	2.9	1	0.5
11	Area 2	3.57	59	28.9	89	43.6	9	4.4	3	1.5	44	21.6	-	-
12	Area 3	**1.25**	12	5.9	1	0.5	-	-	-	-	191	**93.6**	-	-
13	Area 4	3.32	93	**45.6**	20	9.8	21	10.3	-	-	70	34.3	-	-
14	Volume1	3.58	83	**40.7**	54	26.5	15	7.4	2	1.0	50	24.4	-	-
15	Volume2	4.07	118	**57.8**	48	23.5	4	2.0	2	1.0	32	15.7	-	-
16	Volume3	2.39	63	30.9	10	4.9	-	-	2	1.0	129	**63.2**	-	-
17	Time 1	2.63	81	39.7	3	1.5	-	-	-	-	120	58.8	-	-
18	Time 2	**4.73**	187	**91.7**	3	1.5	1	0.5	1	0.5	12	5.9	-	-
19	Time 3	**4.89**	195	**95.5**	3	1.5	2	1.0	-	-	4	2.0	-	-
20	Time 4	2.26	54	26.5	6	2.9	9	4.4	5	2.5	130	**63.7**	-	-
21	Time 5	2.51	48	23.5	13	6.4	8	3.9	61	29.9	74	**36.3**	-	-

The first three questions with the highest average are, 18th question "Which food is cooked quicker?", 19th question "Which bucket is filled quicker?" and "When you walk in a muddy place, is yours or your father's footprint deeper?" as the 9th question. The first three questions with the lowest average are, question 12 "Which stone should I use in order to cover this wall so that I will need more stones?", the third question "A person wearing which shoes should measure this road so that more steps are taken?" and the fourth question "Which red bar did they use to find the result?".

3.2 Questions and examples of answers

In the first question, four thick ropes of the same color and different lengths are put on the table in a mixed way and "Can you order the strings according to their length?" question is asked. Correct answer (total of 5, 4 and 3 scores) percentage is 84.2%. It is observed that 55.4% of the children can make a full explanation, e.g. "*the longest and the shortest, bigger and smaller, from long to short*", for this question. Among the correctly answering children, it was observed that there were children who sorted the ropes only by looking at the ropes and not touching them. Also children generally started from the long rope while sorting. There were also children who looked especially for the shortest rope by preferring just the opposite.10.8% gave an incorrect answer, couldn't make any explanation or made a false explanation.

There are four snakes with different lengths in the picture used in the second question, "Which is the longest snake?". Correct answer (total of 5, 4 and 3 scores) percentage is 98.1%. 42.2% of the children were able to make a full explanation, e.g. "*It's long, others are short*", to this question. 1.4% either gave incorrect answers, couldn't make an explanation or made a false explanation.

While asking the third question which is "A person wearing which shoes should measure this road so that more steps are taken?", a picture of a road and the feet of four people of different dimensions are shown on the same page. Correct answer (total of 5, 4 and 3 scores) percentage is 10.3%. The rate of the children who could make a full explanation, e.g. "*with small step, this person's foot is small*", by answering the question correctly is 8.8%. 89.7% of the children either gave an incorrect answer to the question and couldn't make an explanation, or made a false explanation.

In fourth question about length, there is a black, long and horizontal bar on the top of the page, and two shorter red bars of different lengths at the bottom of the page. The question "Which red bar did they use to find the result?" was asked after making the explanation that the black bar on the page was measured by using one of the red bars and it was of the length of five bars. Correct answer (total of 5, 4 and 3 scores) percentage is 11.8%. While 88.2% of the children answered this question incorrectly, 10.8% were able to answer it correctly and make a full explanation, e.g. "*this is little, they should use small to fill this place, it's small so it's more*". It was observed that children tried to match the bars with the line by their hands and measured them. Furthermore, they were focused on finding both the biggest and smallest bars although this was not asked in the instruction.

Three boxes of the same dimension, same color and different weights were put on the table at the same time, and "Which is the heaviest box?" question was given. Correct answer (total of 5, 4 and 3 scores) percentage is 96.1%. 29.9% of the children were able to answer it correctly and make a full explanation, e.g. "*I tried and found others were light, heavier and lighter".* The rate of those who answered the question incorrectly was found to be 3.9%. Children generally achieved the result with paired comparisons by holding an empty and another box up (full and half-full). In this case, they were asked to look at all of the boxes. Taking a decision by using two hands was sometimes observed. Children generally preferred to understand by holding the boxes up one-by-one.

The page with the horse, sheep, cat and rabbit with equalized dimensions was shown while posing the sixth question, "Which is the heaviest animal?". Correct answer (total of 5, 4 and 3 scores) percentage is 96.6%. While the ratio of the children who answered the question correctly and were able to make a full explanation, e.g. "*It is big and heavy others light, these are light so this is heavy"*, was 47.1%, the ratio of those who answered it incorrectly is 2.9%.

The picture with a cooking pot on one side of the scales and a tea glass, fork, paper towel and jug at the bottom of the page is shown in question seven. Correct answer (total of 5, 4 and 3 scores) percentage is 82.4%. 53.4% of the children answered the "To balance the pot, which can be placed on the other side of the scales?" question completely correctly and make a full explanation, e.g. "*This is heavy like pot, they are same weight and size, these three are light this is heavy*", while 16.1% answered it incorrectly and couldn't make an explanation or made a false explanation.

Before asking the eighth question "Which child is the lightest?", children were allowed to examine a picture showing children riding on a swing. It is explained that children with different weights ride on a swing, and a child wearing a green t-shirt takes another swing and starts to ride with his/her friend. While making this explanation, the second picture is covered when showing the first picture on the page and the first picture is covered when showing the second picture. Correct answer (total of 5, 4 and 3 scores) percentage is 25.5%. 71.6% of the children answered the question incorrectly. The ratio of the children who answered it correctly and were able to make a full explanation, e.g. "*This is light so it's up, light weight up above heavy weight below*" is 20.1%. While making an explanation, children used the concepts of "heavy-light" less than expected. Some of the children had incorrect knowledge just as in the comment "the lighter is below".

The ninth question "When you walk in a muddy place, is yours or your father's footprint deeper?" is asked without showing any picture. Correct answer (total of 5, 4 and 3 scores) percentage is 81.4%. 56.4% of the children correctly answered, however they made an incomplete explanation, e.g. "*My dad is big, his footprint is big, he has huge shoes*". The rate of those who answered the question incorrectly was found to be 18.6%. A great majority of the children who answered it correctly mentioned the large size of their fathers' shoes rather than their weight.

Four papers of differing dimensions and the same color were placed on the table in a mixed way, and "The painting of which paper requires the most paint?" was asked as the 10th question. Correct answer (total of 5, 4 and 3 scores) percentage is 93.7%. 54.9% of the children answered this question correctly and provided a full explanation, e.g. "*Longest*, *this is the most*, *others is little*", while 2.9% answered it incorrectly and couldn't make an explanation or made a false explanation. It was observed that children mostly aligned the papers side-by-side during the application. Nevertheless, there were also children who answered by placing the papers on top of one another. Despite being very low in number, there were also children who achieved the correct answer without touching the papers at all.

The children were told that all four boxes in the picture used in question 11 were of the same size, and each of them contained the same chocolate. Chocolate slices divided into different dimensions and covering the bottom of the box were seen in the boxes. "Which box contains the smallest chocolate pieces?" was the question. Correct answer (total of 5, 4 and 3 scores) percentage is 76.9%. The rate of the children who answered this question correctly but made an incomplete explanation, e.g. "*smallest, shortest, these are the smallest squares, smaller, short*", is 43.6%. The rate of the children who gave an incorrect answer and also had problems in terms of making an explanation is 21.6%. It was observed that children tried to describe the smallness of the pieces with their hands while commenting on this question. They used expressions with their hands such as *"small like this"* while making this description. Despite being low in number, there were also children who tried to count the pieces inside the boxes with a great effort.

In question 12, "Which stone should I use in order to cover this wall so that I will need more stones?", a picture with a blank wall and wall tiles of four different dimensions and the same shape at the bottom of the page was shown. Correct answer (total of 5, 4 and 3 scores) percentage is 6.4%. 93.6% of the children answered the question incorrectly and couldn't make an explanation or made an incorrect explanation, e.g. "*biggest, long, big and heavy"*. The rate of the children who could make a full explanation, by answering the question correctly is 5.9%. Some of the children tried to measure the stones with their hands and place the stones one-by-one when answering the question.

Question 13 “Should an umbrella or a bus stop be chosen in order for more people not to get wet?” was posed after the explanation that it rained heavily outside. Correct answer (total of 5, 4 and 3 scores) percentage is 65.7%. 45.6% of the children were able to make a full explanation, e.g. “*it is the biggest*, long, *the roof is huge*, *many people can fit, wide*”, for this question. 34.3% answered it incorrectly and couldn’t make an explanation, or made a false explanation. A great majority of the children who answered the question correctly made various movements to describe the dimensions of the bus stop with their hands while making an explanation.

Three open boxes of different volumes, the same dimension and color were put on the table at the same time, and question 14 “Which box contains the most ping-pong balls?” was posed. A white ping-pong ball was also put on the table. Correct answer (total of 5, 4 and 3 scores) percentage is 74.6%. While 40.7% of the children answered this question completely correctly, e.g. “*too deep, empty, there is nothing in it, this is wider*”, 24.4% of them answered it incorrectly and had problems in making an explanation. Some of the children put their hands inside the boxes in order to find the answer to the question or made trials by throwing the ball into the boxes again and again. A great majority answered by only looking inside the boxes.

While asking “To which jug should we add more water in order to fill it completely?” as the 15th question to the children, they were shown the picture with four different jugs containing different amounts of water, which were exactly of the same shape and dimension. Correct answer (total of 5, 4 and 3 scores) percentage is 83.3%. 57.8% of the children were able to make a full explanation, e.g. “*At least water in, others full, there is less in it”*, for the question. 15.7% answered it incorrectly and couldn’t make an explanation, or made an incorrect explanation.

While asking the 16th question, “Which books can this bookcase contain more?”, children were shown a picture with a bookcase and four different books of different thickness but with the same height. The explanation that we had so many books and that we could place only the books of a single colour among the four types of books here in the bookcase was made. Correct answer (total of 5, 4 and 3 scores) percentage is 35.8%. 63.2% of the children answered the question incorrectly and couldn’t make an explanation or made a false explanation, e.g. “*thicker, longest, both are yellow, wide”*. The ratio of the children who were able to make a full explanation by answering the question correctly is 30.9%.

There are four burning candles of different lengths in the 17th question, “Which candle burned for a longer time?”. It was stated that the candles were of the same height when they were bought. Correct answer (total of 5, 4 and 3 scores) percentage is 41.2%. 58.8% of the children answered the question incorrectly and couldn’t make an explanation, or made an incorrect explanation, e.g. “*big candle burns most, bigger because it is used more*”. The rate of the children who answered the question correctly and made a full explanation is 39.7%.

A picture with four cooking pots with exactly the same features on four different stoves side-by-side was shown while asking the 18th question, “Which food is cooked quicker?”. Fire burning and different intensities was observed under the cooking pots. It was also explained that the cooking pots were the same, and the same food was cooked inside them. Correct answer (total of 5, 4 and 3 scores) percentage is 93.7%. The rate of the children who answered and provided a complete explanation, e.g. “*most fire, burns much, burns fast*”, the question correctly is 91.7%, while the rate of the children who answered the question incorrectly is 5.8%.

While asking the 19th question, “Which bucket is filled quicker?”, the children were shown a picture with four exactly the same buckets placed under fountains flowing at different densities. Correct answer (total of 5, 4 and 3 scores) percentage is 98%. 95.5% of the children answered this question correctly and made a full explanation, e.g. “*flowing fast, flowing much, they opened the water too much, very thin water*. 2% answered the question incorrectly and couldn’t make an explanation, or made a false explanation.

While asking the 20th question, “Which has come first?”, children were explained that the running times of the runners were recorded and their chronometers were stopped when the runners stopped running. The numbers 4, 5, 6 and 15 are written on the chronometers. Correct answer (total of 5, 4 and 3 scores) percentage is 33.8%. 63.7% of the children answered the question incorrectly and had problems in making an explanation, e.g. “*15 is much, highest chronometer, ran more, higher record*”. The rate of the children who answered the question correctly and were able to make a correct explanation is 26.5%.

No visual was used in 21st question, “Does it take longer to get home by bicycle or by car?”. Correct answer (total of 5, 4 and 3 scores) percentage is 33.8%. 36.3% of the children answered incorrectly and made an incorrect or insufficient explanation, e.g. “*because we have got car*, *car has 4 wheels*”. 23.5% answered the question correctly and were able to make a correct explanation.

3.3 Findings related to variables

The correlation between the gender and month interval variables and the scores taken from the assessment tool was investigated. Since this tool is at the level of the ranking scale, the average scores were compared with the Mann-Whitney U test among non-parametric tests.

Table 3. Mann Whitney U-Test Results of Measurement Reasoning Skills According to Gender and Month interval

Variable		n	Mean rank	Sum of ranks	U	p
Gender	Boy	104	108.11	11243.00	4617.0	.16
	Girl	100	96.67	9667.00		
Month interval	60-65	90	84.86	7637.00	3542.0	**.00**
	66-74	114	116.43	13273.00		

There is no significant difference between the scores taken by boys and girls from the assessment tool (U=4617.0, p>.05). It was determined that children aged 66 months and above took higher scores (U=3542.0, p<.05).

4. Conclusion and Discussion

In the present investigation results showed that, measurement skills were significantly related to children's age but not to gender. There are many research support that, on gender differences in preschool mathematics suggests that children's performance doesn't differ by gender in general terms (Arens et al, 2016; Clark, Sheffield, Wiebe and Espy, 2013; Fisher, Dobbs-Oates, Doctoroff and Arnold, 2012). As known child age may be an important factor in young children's mathematic performance (Purpura and Reid, 2016; Bull and Lee, 2014; Raghubar, Barnes and Hecht, 2010).

In the study, children sometimes gave comparative answers although it was not required in the instruction, and then, they tried to head for the actually required answer. One of the most typical examples of this situation occurred in the question "A person wearing which shoes should measure this road so that more steps are taken?". When the answering percentages to this question were examined, it was observed that they were of lower values when compared to other questions. This question is related to length measurement. What is asked in the question is to find who will take more steps rather than showing the smallest or largest shoes. It is necessary to make a comparison as a first stage in order to achieve the correct answer. However, what is more important than this basic skill is to achieve the rule that "the person with smaller feet take more steps". Children, who didn't pass to the second stage and didn't fully acquire length protection yet, focused on the biggest shoes answer and couldn't exhibit the required reasoning skill.

The literature suggests that at about three years of age, children know that continuous attributes such as mass and length exist, although they may not be able to measure them accurately. By about four or five years of age, children begin to make progress in measuring quantities and start to use words which represent quantity of a certain attribute. Typically children begin with informal measuring processes and units, before measuring using formal tools and units. However, there is evidence to suggest that young children are more familiar with the use of formal processes of measurement. Students may have had experiences with standard units prior to starting school. If teachers are able to access these experiences (or lack thereof) it gives them a better basis upon which to build students' formal understanding of this concept. There is a strong relationship between the richness of the contextual information and the development of measurement understanding (MacDonald, 2013; MacDonald, 2012; MacDonald and Lowrie, 2011).

Weight, which is a concept that is learnt by children by means of experiencing starting from the early periods, was assessed using five questions that utilize verbal, visuals and materials. When the answers and comments of the children in these questions were examined, it was observed that they assessed the sizes and weights of things together.

The questions of "Which red bar did they use to find the result?" and "Which child is the lightest?" that must be relationally compared between the things could be answered correctly by children at the lowest ratio. Children failed to achieve the correct answers and made incorrect comments to the answers given to these questions aiming to find the ways of obtaining these results by giving the results of the length and weight measurements since they only made a comparison. Children gave only conceptual answers by making almost no reasoning at all.

In the question of "Which stone should I use in order to cover this wall so that I will need more stones?", the comparison of the stones' being big and small is the first stage while it is expected to make reasoning on the area (wall) measurement specified at the subsequent stage, just like in the question of "A person wearing which shoes should measure this road so that more steps are taken?". It was observed that the children who failed to comprehend the whole-part relationship and area protection sufficiently yet generally focused on the size evaluation and failed to achieve the expected result. In this respect, it was observed that the children were much more successful in the questions of "The painting of which paper requires the most paint?" and "Which box contains the smallest chocolate pieces?" aiming to make a measurement on the concept of area. The main reason for this is that area protection is based on the concepts of "big-small" and this kind of comparisons is made in these questions in terms of area. As it was also explained before, the question of "Which stone should I use in order to cover this wall so that I will need more stones?" is an upper stage of this situation and thus, it requires mathematical reasoning on the area measurement.

The question of "Should an umbrella or a bus stop be chosen in order for more people not to get wet?" asked to have the children make an area measurement could be answered correctly by the children at a higher rate although it was asked only verbally without showing any material. More than half of the children explained this question by giving answers from their own lives while commenting on this question. However, the remaining part of the children was unable to make a comment on the area concept by sticking to the thought that "only the umbrella can protect from rain."

3-year-olds have been shown to learn the meaning of the word *more* in context of both approximating number and approximating area, suggesting an underlying similarity between these two dimensions (Odic, Pietroski, Hunter, Lidz, and Halberda, 2012). Similarly Odic, Libertus, Feigenson, and Halberda (2013) tested 3- to 6-year-old children and adults in both a number and an area discrimination task. They found that both important similarities and differences in the abilities of young children and adults to represent approximate number and area. Both abilities demonstrate a similar growth pattern, by at least 3 years of age children's area representations are more precise than, and do not correlate with the acuity of their number representations. Like number acuity, area acuity steadily improves during childhood.

Putrawangsa, Lukito, Wijers and Amin's (2014) study suggest that to develop students' understanding of the measurement unit of area the students need to go through the following learning experiences: comparing area of various size of surfaces by using other identical surfaces as tools, comparing area of identical size of surfaces by using other non-identical surfaces as tools, and determining area of gridded surfaces. Those learning experiences are conducted consecutively.

Children were asked to make reasoning about the volumes of the objects in the questions "Which box contains the most ping-pong balls?", "To which jug should we add more water in order to fill it completely?" and "Which books can this bookcase contain more?". It was observed that the children especially had difficulty while answering and explaining the question of "Which books can this bookcase contain more?". The children defined the features (the depth of the boxes, water in the jugs, thin-thick books, etc.) of the objects correctly but they were unable to associate these features with the volume since they could develop the perception of volume protection to a limited extent.

Ebersbach's study (2009) demonstrated that even 5 to 6-year-olds considered the three dimensions width, height, and length of cuboids to quantify their volume and also often integrated these dimensions multiplicatively. 42% of the kindergartners integrated at least two dimensions of the cuboids multiplicatively, and 26% integrated all three dimensions multiplicatively. It can thus be assumed that the ability to combine information multiplicatively is not restricted to only two dimensions in this age but emerges also for three dimensions relatively early.

Vasilyeva, Casey, Dearing, and Ganley (2009) have shown that elementary school students may still have difficulty imposing two and three dimensional units onto continuous expanses of area and volume.

Children were asked the questions of "Which candle burned for a longer time?", "Which food is cooked quicker?", "Which bucket is filled quicker?", "Which has come first?" and "Does it take longer to get home by bicycle or by car?". Among these questions, while the percentage of knowing the questions of "Which food is cooked quicker?" and "Which bucket is filled quicker?" is quite high, this rate drops significantly in other questions.

Time is a concept that is hard to concretize for children. Children may miss the state that various changes occur as time passes. The best example of this is the state of "finding the candle that burns for the longest time" in the question "Which candle burnt for a longer time?". Some of the children showed the candle that was the opposite to the answer saying that "the longest candle will burn for a longer time" by making reverse reasoning. In addition, they answered the question of "Who came first?" saying that it was the runner with the highest number on the chronometer. They explained the state of finding the vehicle that goes home for a longer duration by focusing on the car in the question of "Does it take longer to get home by bicycle or by car?".

In Wilkening and Martin's study (2004), 6 and 10 years of age children and adults were asked about time concept by car experiments. The developmental path to a complete understanding of how speed, time, and distance are interrelated is complex and lengthy. Both in their judgments and in their actions children were wrong when the task required a nonlinear response. Adults, in contrast, appeared to acknowledge the nonlinearity of the physical law in their actions but not in their judgments. When this response mode was required, they seemed to follow the same linearization belief that had been found for the children.

Performing individual applications with the children who participated in the study provided a very fruitful process both for the researcher and the children. The answers of the children were expanded with the question of "why did you think like this?". Thanks to this expansion, the researcher was able to examine the reasoning skills in the field of measurement in-depth.

Whether the answer was correct or incorrect was not important in terms of introspection and indicated that it would be sufficient to ask a question such as "how did you find this" or "what did you tell yourself to find this?" to a child, who gave an answer. In practice, there is no better way that using small mathematical reasoning questions in order to examine the research of the child with inner depth because, in a way, the adult has the ability to see the path that children follow while making reasoning by looking at their answers (Piaget, 2011).

Assessment information can be obtained through observations and interviews as children develop problem solutions. For example, they figure out how to use informal measurement to use construction materials such as unit blocks and Lego to build a desired building or make a desired object. It is critical to observe children's problem solving processes and to question them regarding their thinking in order to understand how they arrived at their solutions (Charlesworth and Leali, 2012).

Children had the chance to express themselves freely in this process. When they were asked for the reasons of their answers, they questioned their own thoughts and they explained the reasons for their reasoning in their own way. Personal evaluations are important both for children and adults, and especially trainers, in order to understand what children think in any area in a more in-depth manner and increase their awareness of their own thoughts. Clarke, Clarke and Roche (2011) and McDonough, Clarke and Clarke (2002) emphasised the benefits of task-oriented and personal assessment in the development of teachers' expertise in understanding the mathematical thinking, its assessment and development.

5. Recommendations

Upon thinking within the scope of the concept of measurement, it is important to make correct definitions using concepts at the estimation stage. However, children should review the data or materials they have by making a comparison at subsequent stages. These stages in question are only possible with real-life experiences or activities that can be as comprehensive as these experiences in which children participate or guide in person.

At the stage of making a measurement with various concrete materials, first, children must be given time to examine the situation they face whatever it is. Since the ability to make a measurement is based on comparing the existing information and data at hand, whether it is performed with non-standard or standard units, children should make a sufficient examination and trials. For example, when comparing the weights of objects, searching the objects in the classroom that will balance each other on the scales, filling or discharging liquids according to the lines in measuring cups, or measuring the lengths of the objects considering the numbers on the ruler can be given as examples. Children need time to focus in these activities, each of which requires careful studying. Children must be provided with an opportunity to make a presentation with concrete materials to explain in front of the group how they have performed a measurement procedure and found an answer.

It is important that children express the results that are obtained by using non-standard or standard units in the measurement activities. That measurement processes are progressed correctly and finding the required result are the most ideal expectation. However, the measurement processes can be more privileged than obtaining results while working especially with small children. At this stage, it must be ensured that children express themselves while measuring. It may be suggested that this process that starts verbally advances towards writing or drawing. Children may illustrate the materials they use while making a measurement and that they measure to small agendas and note the results they obtain with non-standard units such as bucket or glass or numbers.

Educators should perform repeated activities of various types such as music, science and drama for the development of the measurement skills. This approach should also be maintained in the assessment of the measurement skills. In which measurement concept children need support should be observed during the activities and at other times, and it must be examined in a more detailed way with individual assessments to be performed at certain intervals.

The measurement activities that are specified in the literature and applied at schools may also be easily applied at home just as in all other subject headings. Considering the need of the children for personal attention and feedback while making a measurement, it is believed that the games that lead children to make a measurement can be effectively performed at home by means of personal interaction. In this sense, the fact that the guidance required to support the measurement activities performed at school also at home is provided to parents or caregivers is also the responsibility of teachers. Therefore, examples of the measurement activities that children perform in the classroom can be provided and video records can be shown.

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