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Seventh grade students' understanding of linear measurement: what has been learned about linear measurement in seven years of schooling process?

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Abstract

The present study aimed to investigate the extent to which students comprehend the basic concepts and skills of linear measurement. The data were some part of a larger study and collected from 134 seventh grade students attending a public primary school in a medium socio-economic area of Ankara, Turkey through a set of tasks that were designed to challenge students to apply their knowledge and skills about linear measurement in different contexts. Results indicated that an alarming number of the students started with 1, instead of zero, while measuring with a ruler. Most of them did not comprehend the nature of linear measurement. Hence, students' understanding of linear measurement was observed to be still superficial and inadequate, even though linear measurement was introduced to students in the first grade.

Keywords: Length measurement, mathematics education, primary education

1. Introduction

Recently, measurement as a mathematical strand has been receiving considerable amount of attention from mathematics education scholars. Evidence from research studies has revealed poor performance of students on measurement tasks. Several claims have been made on the reasons behind students' shallow knowledge and skills of measurement that might be due to insufficient content, procedurally-dominated measurement instruction, insufficient teachers' knowledge and weaknesses of written curriculum. Furthermore, linear measurement has special cross-links establishing foundational knowledge base for substantial learning in measurement. In other words, understanding the concepts and skills of linear measurement facilitates the understanding of more sophisticated domains of measurement such as area, and volume.

Like in other mathematical domains, students need to acquire such key concepts and skills of linear measurement as unit iteration, partitioning, accumulation of distance, zero-point, comparison, measuring with a ruler, performing conversions, etc. Overall, all of the key concepts and skills are crucial for students to understand linear measurement

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meaningfully and thus, should be explicitly taught. Within the light of the above explanations, the present study aimed to investigate the extent to which students comprehend the basic concepts and skills of linear measurement.

2. Method

The data reported in the present study were part of a larger study and collected from 134 seventh grade students attending a public primary school in a medium socio-economic area of Ankara, Turkey through a set of linear measurement tasks.

2.1. The Participants of the Study

The participants were selected by considering the public primary schools' average mathematics scores in the National Selection Examination for Secondary Education Institutions (OKS) which was a highly-competitive nationwide examination administered at the end of eighth grade, especially for those students who would like to enroll in one of the well-resourced, qualified and prestigious high schools. Based on the range, the minimum, and the maximum scores of the OKS, public primary schools in Ankara were classified as low-, medium-, and high-achieving schools and then, one of the medium-achieving schools (Average Math Score: 5.35) located in one of the main districts of Ankara was selected for the study. All seventh grade students (N = 134) attending this school constituted the participants of this study. As given in table 1, out of 134 seventh grade students, 66 of them were male (49.3%) and 68 were female (50.7%). Their ages ranged between 13 – 15 and most of them (N=112, 84%) were 13 years old.

Table 1. Background Information about the Students

Background information	*f*	%
Gender		
Female	68	50.7
Male	66	49.3
Age		
13 years old	112	83.6
14 years old	20	14.9
15 years old	2	1.5
Mathematics Report Card Grade in 6th Grade		
High-achievers	73	54.4
Average-achievers	32	24
Low-achievers	29	21.6

** The students' mathematics report card grade ranges from 5 to 1 and descriptors for 5 – 4 (high-achievers) is great, 3(average-achievers) is satisfactory, and 2-1(low-achievers) is need improvement.*

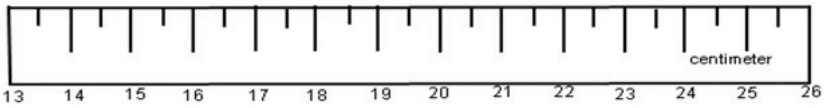
2.2. Data Collection Instrument and Procedure

As stated previously, the data reported here was part of the larger research study focusing on length, area, and volume measurement. Thus, five tasks on length measurement developed by the researchers [apart from one task adapted from Hart's study (1981)] were reported in the present study. The tasks were designed to examine the extent to which the students comprehend the underpinnings of length measurement as well as applying measurement procedures. During the development process, the existing research on the learning and teaching of length measurement and the study of length measurement in the Turkish Primary Mathematics Curriculum (from the learning objectives to the content), were analyzed in a detailed manner so as to develop the tasks which should be parallel to students' developmental levels and should cover the content of length measurement in the six-year of schooling period. A scoring key was prepared by the researchers where 1 point was assigned for the correct answer and 0 for both the incorrect answer and blank question.

3. Results

The analysis of the broken ruler task (Figure 1) revealed that about 40% ($N = 52$) of the 7th grade students found the length of a broken ruler correctly. When their written responses were examined, it was observed that students either counted the numbers, instead of intervals or reported the last number on the ruler as the length of the ruler. Considering students' grade level, it was surprising that some of the students summed all of the numbers on the broken ruler (13 + 14 +….+26) in order to find the length.

Task 1:
Carol's centimeter ruler is broken and all that she has is shown above. Please answer the following the questions.



a) Find the length of Carol's broken ruler and explain how you found it.
b) Suppose you measure 2 meters of cloth. Is it possible to measure 2 meters of cloth with Carol's broken ruler? If so, describe how. If not, explain why not.

Figure 1. Task 1-Broken Ruler

Among 134 seventh graders, 90 of them (67.2%) stated that it does not matter whether it is broken, it is measurable. Those who missed this question (N = 44, 32.8%) believed that since the ruler is broken, it lost its function and is not enough to measure a 2-meter-long cloth.

The second task (Figure 2) was adapted from Hart's study (1981). The data analysis indicated that whereas the number of students who paid attention to the measuring tool (*subtask a*) was only 45 (33.6%), a majority of the students (*subtask b* N=75, 56%; *subtask c* N= 105, 78.4%) correctly compared the strings which were measured by the same tool.

Task 2
The length of the string A and B were measured by using a wooden stick and the length of the string C and D were measured by using plastic stick. The lengths of all strings are presented in the table below.

Strings	Lengths
A	11 wooden stick
B	9.5 wooden stick
C	11 plastic stick
D	14.5 plastic stick

☛ After carefully examining the table, answer the following questions.

a) The lengths of the string A and C are equal.
☐ Correct ☐ False ☐ We cannot make any comments about the lengths of the strings.

b) The length of the string D is longer than the string C.
☐ Correct ☐ False ☐ We cannot make any comments about the lengths of the strings.

c) The length of the string B is shorter than the string A.
☐ Correct ☐ False ☐ We cannot make any comments about the lengths of the strings.

Figure 2. Task 2 – Comparison of the Strings' Length

In the 3rd task (Figure 3), although, 66% of the students (*N*=88) stated that the given ruler is made inaccurately, a majority of the students (N=106, 80%) stated Randy's conclusion "There are 10 millimeters in a centimeter" is correct.

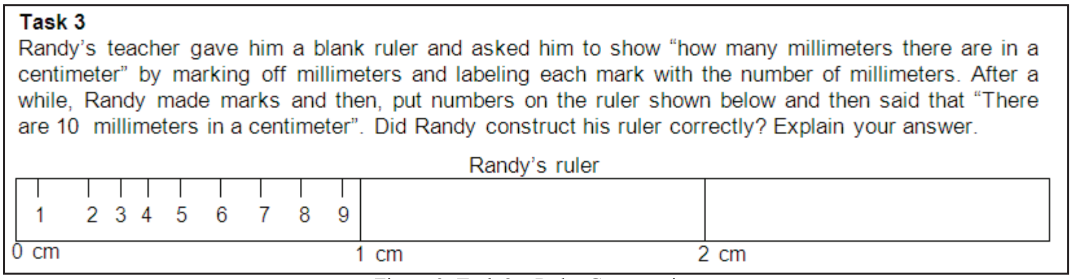


Figure 3. Task 3 – Ruler Construction

The fourth task related to the use of a ruler. According to the findings, 66.4% of the seventh graders (*N*=89) were able to use a ruler correctly to measure the line segment which is 13 cm long.

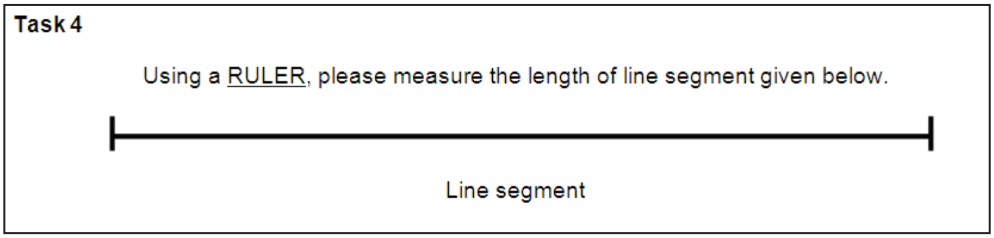


Figure 4. Task 4 – Measuring with a ruler

Those who missed the task made similar mistakes as the broken ruler task (e.g. counting the numbers on the ruler, reporting the last number matching the end point of the segment as the length, etc.). In the last task, the students were asked to choose the most appropriate units of measurement for the following attributes: (a) the distance between two cities; (b) the perimeter of your blackboard; and (c) the width of 1Turkish Lira. According to the findings, almost all of the students (93.3%, N=125) stated that the most appropriate unit of length measurement for the distance between two cities was kilometer; for the perimeter of your blackboard was meter (53.7%, N=72); and for the width of 1Turkish Lira was millimeter (58.2%; N=78).

4. Conclusion

In this study, seventh grade students' comprehension of linear measurement was assessed through a set of tasks. The findings clearly indicated that the students' linear measurement knowledge and skills was quite shallow and insufficient. Despite length measurement is a significant part of the Turkish National Mathematics curriculum and is begun to be taught from first grade to eighth grade (Tan-Sisman & Aksu, 2011), some of the seventh graders still started from 1 rather than 0 while engaging with a ruler; counted either marks or numbers on a ruler instead of intervals; reported the last number as the length of ruler; mixed units of length measurement, and had problems with the relationship between the attribute and a unit of measurement. In the mathematics education literature, similar student difficulties were also reported by several scholars (e.g. Barrett et al., 2006; Boulton-Lewis et al., 1996; Heraud, 1989; Kamii, 1995; Schrage, 2000).

Although the students indicated that they can perform reasonably successfully on traditional tasks (e.g. use of a ruler), they did not master such fundamental concepts of linear measurement as zero-point, iteration, and the structure of a ruler. At this point, it might be argued that the findings might be the indicators of inadequacy of written curriculum, teachers, instruction and assessment process. For the inadequacy in mathematics curriculum, it is suggested that the fundamental aspects of length measurement should be both placed explicitly on the content of length measurement and embedded in the instructional activities by considering common errors of students. From the students' explanations, it might be argued that the delivery of length measurement seemed to be more procedurally-oriented, and thus it is suggested that the instructional activities should be enriched by focusing on the fundamental concepts of length measurement and designing such activities as constructing a ruler, measuring with a broken ruler, etc. that highlights the links between concepts and skills. Moreover, the inadequacy in assessment process might be improved by putting more emphasis not only on the effective use of formative assessment that has a great positive impact on student learning (Black & William, 1998; Williams & Ryan, 2000) and also the quality of mathematical tasks which should enable teacher to better diagnose students' difficulties.

Finally, considering the importance of length measurement in understanding area and volume measurement, it might be argued that unless students are provided with learning opportunities that facilitate the acquisition and coordination of the concepts and skills about length measurement, the poor performance on area and volume measurement will be unavoidable.

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