KOTTS in Enhancing Primary Pupils' Problem Solving Abilities in Addition and Subtraction Operations of Measurement

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Abstract

Purpose and Research Question - This research aimed to examine the effectiveness of using '*Kit Operasi Tambah Tolak Sukatan'* (KOTTS) in enhancing primary pupils' problem-solving abilities in addition and subtraction operations of measurement. In particular, the significant difference between the pretest mean scores and the posttest mean scores was investigated. The mean time taken by the pupils to complete the pretest and the posttest was also compared.

Methodology – The quasi-experimental research design was used in this research whereby KOTTS was used as an intervention teaching and learning tool. 176 Year 5 and Year 6 primary pupils and 62 Form 1 secondary school students were selected from eight primary schools and four secondary schools in the Tuaran district of Sabah using the purposive sampling technique involved in this research. A self-developed pretest and posttest were used to measure primary pupils' problem-solving abilities in addition and subtraction operations of measurement. The Wilcoxon signed ranks test was used to test the identified null hypotheses at alpha =.05.

Findings – This research revealed that there was a significant difference between the pretest mean scores and the posttest mean scores. Primary pupils' posttest mean scores were significantly higher than their respective pretest mean scores. It was also found that primary pupils spent less time (60.5%) completing the posttest as compared to the pretest.

Significance and Contribution in Line with Philosophy of LSM Journal - It was evident from this research that '*Kit Operasi Tambah Tolak Sukatan*' (KOTTS)(with an exemplar provided in Appendix) is an effective teaching and learning tool to enhance primary pupils' problem-solving abilities in addition and subtraction operations of measurement. KOTTS provides an alternative teaching and learning tool for mathematics teachers to enhance problem-solving abilities in 'addition and subtraction' operations of measurement among primary pupils. Based on the findings of PGPK and PMPK by respondents of quantitative and qualitative studies and conclusions that have been made, it is appropriate that such innovative materials can be further expanded so that students can learn through the use of KOTTS. In general, this KOTTS is able to attract and have learning elements that are very useful to mathematics remedial students. Hopefully this KOTTS innovation material can be used to make hands-on knowledge delivery a trend, just like the active learning pedagogy by Curriculum Development Division.

Keywords: Addition and subtraction operations of measurement; Length unit; Liquid volume unit; Mass unit

Introduction

Mathematics is an abstract concept (Lieberk, 2015) and the most difficult subject (Saad, 2015) compared to other school subjects. Problem-solving in mathematics involves the use of formulae, working steps, algorithm, and frequently used theorem (Short & Spanos, 1989). Mathematics is a subject with its own unique and specific language (Jamil Ahmad & Norlia Goolamally, 2008). Although it is often said that the language used in mathematics is simple, but it has specific meanings for mathematics learning. The specific mathematics language involves the explanation of patterns, relationships, rules, and formulae that need to be remembered. Therefore, mathematics language plays an important role in transferring the obtained information from a teacher to his/her students (MacGregor & Moore, 1991). On the other hand, it is very important that math teachers know how to teach mathematics and use structured language to keep students from making assumptions or getting things wrong about what they are being taught (Tikunoff, 1985).

Background of the study

The primary school syllabus was revised in 1998 to enable primary school pupils to learn basic skills in mathematics (Curriculum Development Centre, 2006). One of the important topics in the mathematics syllabus is measurement. This means that all students need to learn about this topic so that they can use it to solve measurement problems in their everyday lives (Mok, 2004).

Teachers play an important role in nurturing holistic human capital with knowledge and moral values. As stipulated in the Malaysian Education Blueprint (PPPM) (2013-2025), the Malaysian education system aims to produce students based on six aspirations: knowledge, thinking skills, leading skills, bilingual skills, ethics, spirituality, and national identity. As a result, teachers are the agents who help students achieve their goals (*Tema Hari Guru* 2015, 2015).

To achieve these aspirations, the role of teachers is not limited to conveying the content of the syllabus in the classroom, but also to being creative and innovative in knowledge development in line with technology advancement and future needs through student-centered teaching practice and the effective use of resources. Thus, a lecturer of mathematics needs to be a role model for the trainee teachers to create a wide range of innovative products to solve the various problems faced by school students.

Problem statement

Usually, weak or left-behind pupils show disinterest in learning mathematics. They do not understand the mathematical concepts taught to them and hence start to make noise and create problems which disturb the teaching and learning process. Specifically, these pupils often take longer time to solve problems related to measurement that involve addition and subtraction operations. They start to feel bored and demotivated about answering the mathematical questions correctly due to their incompetency in unit conversion.

The required skills involved in the unit conversion of length, mass, and liquid volume are prerequisites and crucial to assist pupils in solving problems related to measurement involving addition and subtraction operations. Hence, this study has suggested an intervention to assist mathematics-weak pupils to learn the required skills in unit conversion and become capable of solving problems related to measurement.

Research objectives

This study strives to achieve six objectives:

i) to gauge pupils' pretest scores before the use of KOTTS;
ii) to gauge pupils' posttest scores after the use of KOTTS;
iii) to identify pupils' perceptions on the use of KOTTS in solving problems related to addition and subtraction operations of measurement;
iv) to identify teachers' perceptions on the use of KOTTS in assisting pupils to solve problems related to addition and subtraction operations of measurement;
v) to examine if there is a significant difference in the mean scores of pretest and posttest before and after the use of KOTTS among primary school pupils;
vi) to examine if there is a significant difference in the mean time needed to solve problems related to measurement before and after the use of KOTTS among primary school pupils.

Research hypotheses

Two null hypotheses to be tested at the significance level, alpha = .05 are:

Ho_1: There is no significant difference in the mean scores of pretest and posttest before and after the use of KOTTS among primary school pupils.

Ho_2: There is no significant difference in the mean time needed to solve problems related to measurement before and after the use of KOTTS among primary school pupils.

Literature Review

The use of teaching and learning materials can stimulate pupils' interests and curiosity to know more about a specific learning content and hence make the learning process more interesting and effective (Mat Nor Hussin & Abd. Rahman Abd. Rashid, 1988). Teaching and learning materials are an effective way to enhance the learning process among learners (Heinich et al., 1996). The effectiveness of a teaching and learning session is not only directly related to the characteristics and the conditions of the teachers and their pupils, but also depends on the pupils' senses, which have been involved during the teaching and learning process. So, using teaching and learning materials engages the different senses of the students and helps them learn better.

According to Lai et al. (2001), the quality of a student-centered lesson depends heavily on how effectively a teacher selects and uses a suitable teaching aid. Mathematics teachers seldom use a teaching aid to teach mass (40.5%) and liquid volume (46.4%). 95% of the mathematics teachers agreed that the use of teaching aids is extremely important in arousing students' interest and curiosity in learning mathematics and enhancing students' understanding of mathematical concepts taught to them. The effective use of various teaching aids focuses students' attention toward learning mathematics and facilitates the delivery of mathematical concepts by teachers to their students.

Methodology

Research design

The quasi-experimental research design was used in this research whereby KOTTS was used as an intervention teaching and learning tool. 176 Year 5 and Year 6 primary pupils and 62 Form 1 secondary school students were selected from eight primary schools and four secondary schools in the Tuaran district of Sabah using the purposive sampling technique involved in this research. A self-developed pretest and posttest were used to measure primary pupils' problem-solving abilities in addition and subtraction of measurements. The Paired-sample Wilcoxon test was used to test the identified null hypotheses at alpha =.05.

Research instruments

Research instruments used to collect quantitative data in this study are:

i) Pretest;
ii) Posttest;
iii) Pupils' Perceptions on the Use of KOTTS Questionnaire (PMPK); and
iv) Teachers' Perceptions on the Use of KOTTS Questionnaire (PGPK).

Pretest and posttest

The pretest and posttest used in this study were self-developed paper-and-pencil tests. Twelve open-ended mathematics items have been developed based on the Curriculum Specification of the Integrated Curriculum for Primary School (KBSR) Mathematics (Curriculum Development Centre, 2006). Table 1 shows how the math questions on the pretest and posttest were spread out by the skills being tested.

Table 1 Item Distribution in the Pretest and Posttest

Item	Skills
1	Addition Operation: meter and centimeter (involving decimals) to meter
2	Addition Operation: centimeter and millimeter to millimeter
3	Addition Operation: kilometer and meter (involving decimals) to kilometer and meter
4	Subtraction Operation: kilometer and meter to kilometer
5	Subtraction Operation: meter and centimeter (involving decimals) to meter and centimeter.
6	Subtraction Operation: centimeter and millimeter to centimeter
7	Addition Operation: kilometer, meter, centimeter, and millimeter to centimeter
8	Subtraction Operation: kilometer, meter, and centimeter (involving decimals) to meter
9	Addition Operation: kilogram and gram (involving decimals) to kilogram
10	Subtraction Operation: kilogram and gram (involving decimals) to kilogram
11	Addition Operation: liter and milliliter (involving decimals) to liter
12	Subtraction Operation: liter and milliliter (involving decimals) to liter

Pupils' perceptions on the use of KOTTS questionnaire (PMPK)

PMPK, a self-developed questionnaire, consists of 22 items to gauge pupils' perceptions of the use of KOTTS. A 4 point-Likert scale (1 = strongly disagree, 2 = disagree, 3 = agree, 4 =

strongly agree) was used to show pupils' degree of agreement on each of the questionnaire items. The higher score denotes a more positive perception of the use of KOTTS.

Teachers' perceptions on the use of KOTTS questionnaire

PGPK, a self-developed questionnaire, consists of 22 items to gauge teachers' perceptions of the use of KOTTS. A 4 point-Likert scale (1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree) was used to show teachers' degree of agreement on each of the questionnaire items. The higher score denotes a more positive perception of the use of KOTTS.

Level of Respondent's Agreement to the Use of KOTTS

Table 2 shows the scale of agreement level used to interpret the findings of Teachers' Perceptions on the Use of KOTTS (PGPK) and Students' Perceptions on the Use of KOTTS (PMPK). A mean score between 1.00 and 1.75 indicates a level of "Strongly Disagree" with the use of KOTTS. A mean score between 1.76 and 2.50 indicates a level of "disagree" with the use of KOTTS. Meanwhile, the mean score of 2.51–3.25 indicates the level of "Agree" to the use of KOTTS. Finally, a mean score of 3.26–4.00 indicates a level of "Strongly Agree" on the use of KOTTS.

Table 2 Scale of Agreement Level

Scale	Level of Agreement
1.00 – 1.75	Strongly Disagree
1.76 – 2.50	Disagree
2.51 – 3.25	Agree
3.26 – 4.00	Strongly Agree

Data Analysis Procedures

Prior to statistical analysis, incomplete questionnaires were identified and excluded from subsequent analysis. All valid data was then analysed using descriptive statistics (frequency, percentage, mean, standard deviation) and inferential statistics (Wilcoxon signed ranks test) via IBM SPSS for Windows version 21. A significance level, alpha =.05, was chosen to allow 5% of error in inferential statistical analysis.

Findings

Reliability Analysis of the Instruments

All collected data was analysed using IBM SPSS for Windows version 21 to perform the reliability analysis of the instruments. Table 3 shows the number of items and the Cronbach's alpha coefficient for each respective instrument used in the study.

Table 3 Number of Item and Cronbach's Alpha Coefficients for the Instruments

Instrument	Number of Items	Cronbach's Alpha Coefficients
PMPK	22	.899
PGPK	22	.969

The Cronbach's alpha coefficients of two questionnaires are considered acceptable for a reliable instrument. A reliable instrument also has high validity (Stanley & Hopkins, 1972).

Pupil's Level of Mathematics Achievement before the Use of KOTTS

Prior to the use of KOTTS, pretest results showed that only 2.7% of the pupils were categorised in the "low" category and 14.5% in the "very low" category. As measured by the pretest administered to them, 82.8% of the pupils have not mastered the addition and subtraction operations of measurement. Table 4 shows the frequency distribution and percentage according to the mastery level of measurement (length, mass, and liquid volume) before the use of KOTTS.

Table 4 Frequency Distribution and Percentages according to Mastery Level of Measurement in the Pretest

Grade	Mastery Level	Range	Frequency	%
A	Very High	85 - 100	0	0
B	High	70 – 84	0	0
C	Moderate	60 - 69	0	0
D	Low	50 - 59	6	2.7
E	Very Low	40 – 49	32	14.5
F	Nil	0 - 39	183	82.8
	Total		221	100.0

Pupils' Level of Mathematics Achievement after the Use of KOTTS

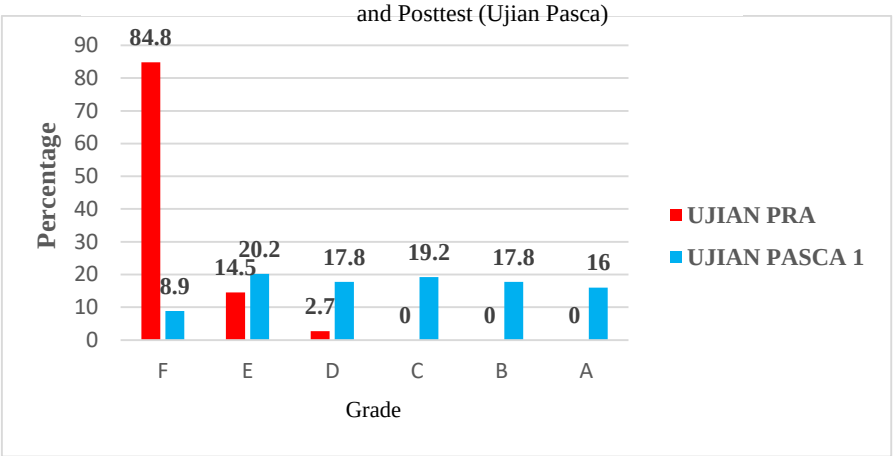
After the use of KOTTS, posttest results have shown that 16.0% of the pupils were categorised in the "very high" category and 17.8% in the "high" category. The posttest that was given to the students showed that only 8.9% of them had not learned how to add and subtract measurements.

Table 5 shows the frequency distribution and percentage according to the mastery level of measurement (length, mass, and liquid volume) before the use of KOTTS. Figure 3 shows a comparison of pupils' mastery level of measurement between the pretest and posttest.

Table 5 Frequency Distribution and Percentages according to Mastery Level of Measurement in the Posttest

Grade	Mastery Level	Range	Frequency	%
A	Very High	85 - 100	34	16.0
B	High	70 – 84	38	17.8
C	Moderate	60 - 69	41	19.2
D	Low	50 - 59	38	17.8
E	Very Low	40 – 49	43	20.2
F	Nil	0 - 39	19	8.9
	Total		213	100.0

Figure 3 Comparison of Pupils' Mastery Level of Measurement between Pretest (Ujian Pra) and Posttest (Ujian Pasca)



Pupils' Perceptions on the Use of KOTTS in Solving Problem Related to Measurement

Based on the analysis of pupils' perceptions of the use of KOTTS as shown in Table 6, the overall percentage of agreement for the 22 items is 98.0%.

Table 6 Pupils' Perceptions of the Use of KOTTS (N = 220)

No.	Statement	Mean	SD	% Agreement
1	KOTTS enables pupils to solve problems related to length measurement (example: km, m, cm, mm) involving addition and subtraction operations…			
a	effective	3.70	0.481	99.1
b	fast	3.48	0.519	99.1
c	easy	3.68	0.478	99.5
d	time-saving	3.48	0.600	94.5
e	accurate answer	3.39	0.582	95.0
f	satisfying	3.75	0.447	99.5
2	KOTTS enables pupils to solve problems related to mass measurement (example: kg, g) involving addition and subtraction operations…			
a	effective	3.62	0.522	98.2
b	fast	3.50	0.553	97.3
c	easy	3.60	0.508	99.1
d	time-saving	3.45	0.583	95.5
e	accurate answer	3.43	0.548	97.3

No.	Statement	Mean	SD	% Agreement
f	satisfying	3.68	0.488	99.1
3	KOTTS enables pupils to solve problems related to liquid volume measurement (example: l, ml) involving addition and subtraction operations…..			
a	effective	3.60	0.517	98.6
b	fast	3.49	0.553	97.3
c	easy	3.63	0.493	99.5
d	time-saving	3.46	0.600	94.5
e	accurate answer	3.45	0.559	96.8
f	satisfying	3.66	0.485	99.5
4	KOTTS attracts pupils' interest to solve problems related to measurement (length, mass, volume).	3.71	0.482	98.6
5	I find that KOTTS materials are interesting.	3.74	0.459	99.1
6	I find that KOTTS materials are attractive	3.69	0.472	99.5
7	I will use KOTTS to solve problem-related to measurement (length, mass, volume) in the future.	3.78	0.425	99.5
	Overall	**3.59**	**0.516**	**98.0**

Teachers' Perceptions on the Use of KOTTS in Assisting Pupils to Solve Problem Related to Measurement

Based on the analysis of teachers' perceptions on the use of KOTTS as shown in Table 7, the overall percentage of agreement for the 22 items is 99.86%.

Table 7 Teachers' Perceptions of the Use of KOTTS (N = 223)

No.	Statement	Mean	SD	% Agreement
1	KOTTS can assist pupils to solve problems related to length measurement (example: km, m, cm, mm) involving addition and subtraction operations…..			
a	effective	3.72	.449	100.0
b	fast	3.78	.412	100.0
c	easy	3.77	.421	100.0
d	time-saving	3.80	.402	100.0
e	accurate answer	3.64	.482	100.0

No.	Statement	Mean	SD	% Agreement
f	satisfying	3.67	.481	99.6
2	KOTTS can assist pupils to solve problems related to mass measurement (example: kg, g) involving addition and subtraction operations…..			
a	effective	3.72	.449	100.0
b	fast	3.81	.392	100.0
c	easy	3.81	.395	100.0
d	time-saving	3.79	.406	100.0
e	accurate answer	3.65	.478	100.0
f	satisfying	3.69	.465	100.0
3	KOTTS can assist pupils to solve problems related to liquid volume measurement (example: l, ml) involving addition and subtraction operations…..			
a	effective	3.75	.445	99.6
b	fast	3.81	.392	100.0
c	easy	3.82	.388	100.0
d	time-saving	3.80	.402	100.0
e	accurate answer	3.66	.475	100.0
f	satisfying	3.71	.455	100.0
4	KOTTS attracts pupils' interest to solve problems related to measurement (length, mass, volume).	3.76	.429	100.0
5	I find that KOTTS materials are interesting.	3.71	.473	99.1
6	I find that KOTTS materials are attractive	3.71	.482	98.7
7	I will use KOTTS to assist my pupils to solve problem-related to measurement (length, mass, volume) in the future.	3.70	.458	100.0
	Overall % of Agreement	**3.74**	**.438**	**99.86**

Differences between Pretest and Posttest Mean Scores

In this study, the Wilcoxon signed ranks test was used to test the first null hypothesis at the significance level, alpha =.05. Table 8 shows the descriptive statistics (mean and standard deviation) of pupils' mathematics achievement in the pretest and posttest. The result showed

that the posttest mean score is higher as compared to the pretest mean score. The maximum possible score for the pretest and posttest is 100, respectively.

Table 8 Descriptive Statistics of Pupils' Mathematics Achievement in the Pretest and Posttest

Achievement Test	Mean	Standard Deviation
Pretest	11.16	10.731
Posttest	56.42	24.356

The Wilcoxon signed rank test (Table 9) yielded a significant result (z = -12.504, p<.05). The first null hypothesis, which stated that 'There is no significant difference in the mean scores of pretest and posttest before and after the use of KOTTS among primary school pupils', has been rejected successfully. Hence, it can be concluded that a significant difference exists in the mean scores of pretest and posttest before and after the use of KOTTS among primary school pupils. The posttest mean score is higher than the pretest mean score. In other words, KOTTS helps students get better at solving problems that have to do with measuring.

Table 9 Wilcoxon Signed Ranks Test Result[s]

	Posttest scores – Pretest scores
Z	-12.504[b]
Asymp. Sig. (2-tailed)	**.000**

a. Wilcoxon Signed Ranks Test
b. Based on negative ranks.

The difference in the Time Needed to Solve Problem Related to Measurement Before and After the Use of KOTTS

In this study, the Wilcoxon signed ranks test was used to test the second null hypothesis at the significance level, alpha =.05. Table 10 shows the descriptive statistics (mean and standard deviation) of the time needed to solve problems related to measurement in the pretest and posttest. The result showed that primary pupils took less time to solve problems in the posttest as compared to the pretest.

Table 10 Descriptive Statistics of Time Needed to Solve Problem Related to Measurement in the Pretest and Posttest

Achievement Test	Mean (Minutes)	Standard Deviation
Pretest	4.76	202.674
Posttest	1.88	24.180

The Wilcoxon signed rank test (Table 11) revealed a significant result (z =-11.125, p<.05). The second null hypothesis, which stated that 'There is no significant difference in the meantime needed to solve problems related to measurement before and after the use of KOTTS among primary school pupils', has been rejected successfully. Hence, it can be concluded that a

significant difference exists in the meantime needed to solve problems related to measurement before and after the use of KOTTS among primary school pupils. Primary pupils took less time (60.5%) to solve problems in the posttest as compared to the pretest. In other words, KOTTS is time-saving in solving problems-related to measurement.

Table 11 Wilcoxon Signed Ranks Test Result[a]

	Time Needed in Posttest – Time Needed in Pretest
Z	-11.125[b]
Asymp. Sig. (2-tailed)	**.000**

a. Wilcoxon Signed Ranks Test
b. Based on negative ranks.

Discussion

The research found that the mastery level of mathematics remedial pupils has improved. In addition, mathematics remedial students can also solve problems related to measurement. It can be concluded that the use of KOTTS has successfully corrected the mistakes made by the pupils. Then, students will be able to solve measurement problems correctly even if they don't use KOTTS.

On the other hand, KOTTS has benefited both teachers and pupils by saving the time needed to solve problems related to measurement. This is due to the fact that pupils have been introduced to the correct techniques and procedures for using KOTTS. KOTTS has also saved teachers a lot of time because they do not have to correct the mistakes made by the pupils. Teachers can use KOTTS to teach students all the skills they need to solve measurement problems in a short amount of time.

Pupils are satisfied when solving problems related to measurement with the use of KOTTS. After being exposed to the use of KOTTS, pupils also found that KOTTS is an interesting and innovative learning tool. On the other hand, teachers are also satisfied with the pupils' performance after the use of KOTTS as most of the pupils have mastered the required skills to solve problems related to measurement. This innovation matches the words set out in the National Policy on Education (1992), as quoted by Manpal Singh (2004), "to emphasise the use of teaching and learning aids, especially the improved materials, to ensure more effective and realistic teaching and learning in the classroom." Based on the research results, it is clear that KOTTS can be recommended as an effective teaching and learning tool to help students in math remediation solve measurement problems.

Conclusions

Based on the findings of PGPK and PMPK answered by teachers and students, quantitative and qualitative studies and conclusions that have been made, it is appropriate that such innovative materials can be further expanded so that students can learn through the use of KOTTS. This is because, overall, this KOTTS is able to attract interest as well as have learning elements that are very useful to mathematics remedial students. Lastly, the researchers hope that this KOTTS

innovation material can be used to make hands-on knowledge delivery a trend, just like the Curriculum Development Division's active learning pedagogy.

Overall, KOTTS succeeded in producing interventions that had a positive impact on the teaching and learning of the topics studied. There is no doubt that the introduction of skills to solve the measurement questions by using KOTTS can improve student achievement compared to traditional teaching and learning methods (Chalk and talk). The programme also successfully implements three main domains, namely cognitive, psychomotor, and affective, in addition to forming a superior personality and personality in line with the aspirations of the National Education Philosophy and further producing intelligent, creative, and innovative human capital to meet the challenges of the 21st century so that the country can compete on the world stage. Therefore, researchers have suggested the use of KOTTS to solve measurement questions.

Acknowledgments

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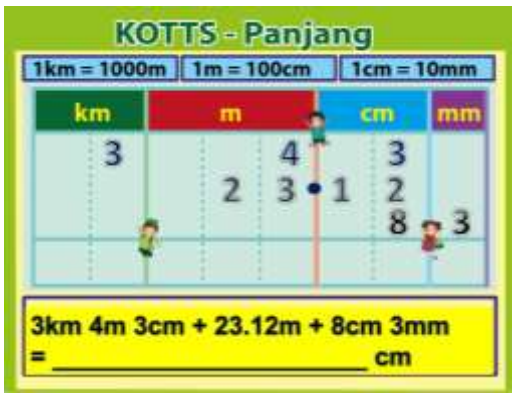
Appendix: KOTTS Method (Length)



Step 1:
Write all the numbers according to their respective units

Step 2:
Throw away the decimal point. Then, add in zeros in the empty spaces in between the numbers.

Step 3:
Add up the numbers to get the final answer.

Then put a decimal point on the border of the unit as reflected on the final answer.

The final answer is in cm unit.

So, put a decimal point on the boarder of cm unit.