Reflection on a Lesson Study for Enhancing Students' Problem Solving Competence through the Bar Model method

Educational Research Sharing

Our School

FUKIEN SECONDARY SCHOOL AFFILIATED SCHOOL
福 建 中 學 附 屬 學 校
FSSAS

- **Hong Kong DSS School**
- **EMI School**
- **The school aims to provide a humanistic inclusive education**

Objective of our department

FUKIEN SECONDARY SCHOOL AFFILIATED SCHOOL
福 建 中 學 附 屬 學 校
FSSAS

- **Stimulate the interest** of pupils in the learning of mathematics
- **Develop pupils' understanding** and acquisition of basic mathematical concepts and computational skills

Agenda

1. Research Background & Question
2. Methodology
3. Findings
4. Limitation
5. Follow up works done

Research Background

Educators believe that the purpose of mathematics education is problem solving, which is one of the most important competences for 21st century education.

Curriculum Development Council (CDC) (2000).
Mathematics curriculum guide (P1-P6).
HKSAR: The Education Department.

Research Background

Research found that students encountered different levels of difficulties in understanding word problems.

Ng S.W., & Lee K. (2009). The model method: Singapore children's tool for representing and solving algebraic word problems. *Journal for Research in Mathematics Education*, 40(3), 282 -313.

Research found that students encountered different levels of difficulties in how the quantities relate to each other, using mathematical symbols to represent knowns and unknowns, and in choosing suitable strategies to handle word problems.

Kho, T. H., Yeo, S. M., & Fan, L. (2014). Model method in Singapore primary mathematics textbooks. International Conference on Mathematics Textbook Research and Development 2014, 29-31 July 2014, University of Southampton, UK.

Research Background

The bar model method is a well-developed tool helping students to solve structurally complex mathematical problems developed by the Curriculum Development Institute of Singapore, Ministry of Education in the 1980s.

Kho, T. H., Yeo, S. M., & Lim, J. (2009). *The Singapore model method for learning mathematics*. Singapore: Marshall Cavendish Education.

Research Question:

A series of systemically scaffolding worksheets for Primary 1 to 6 students were designed for use in the 2018/19 school year.
This study aims to find out:

1. **to what extent the bar model method can help students improve their performance in solving mathematical word problems; and**

2. **to what extent the bar model method can affect students' attitude towards problem-solving in mathematics.**

Methodology (Quantitative)

A Primary four class (n=24) was selected from 5 Primary four classes with similar background in terms of numbers of students, abilities and learning diversity.

Students' performance scores in specially designed worksheets were collected afterwards.

They were asked to describe their attitude towards problem-solving using the Attitude Inventory Item questionnaire.

Data collection

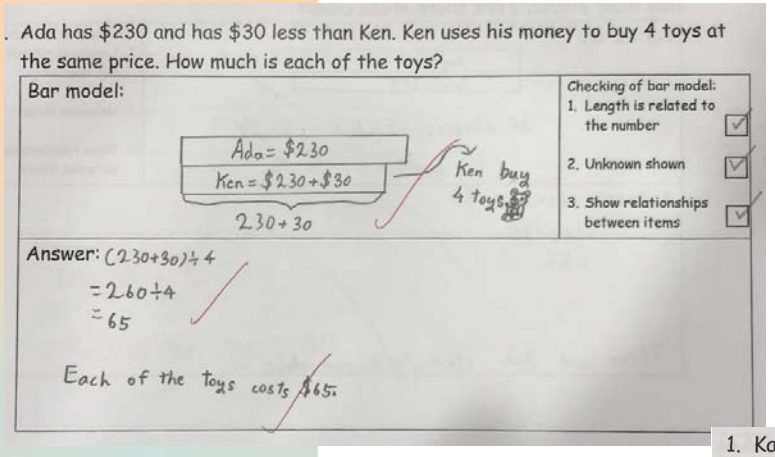
A series of lessons (5 lessons) were designed to equip students with a mastery of the bar model drawing skills, and to develop their problem-solving skills through the use of the bar model method.

Lesson	**Type of bar model**	**Objective**	**Example**
1	Multiplicative comparison models	Multiplications (Self-checking)	There are 12 camps in the campsite. There are 24 beds in each camp. How many beds are there in the campsite?
2	Before-after models	Divisions (Self-checking)	93 pupils are divided into 18 groups equally on Fun Day. The remaining pupils join the last group. How many pupils are there in the last group?

Data collection

Lesson	Type of bar model	Objective	Example
3	Comparison models involving addition and division	Mixed-operations (Peer-checking)	There are 28 cans of milk tea in each box. There are 7 fewer cans of milk tea than green tea in each box. A convenience store buys 280 cans of green tea. How many boxes of green tea does the store get?
4	Comparison models involving subtraction and division	Mixed-operations (Peer-checking)	Mary has 100 apples. Mary has 10 apples more than Peter. Peter will share his apples with 8 of his friends. How many apple(s) will Peter have finally?
5	Comparison models involving multiplication and division	Mixed-operations (Peer-checking)	The price of 4 bags of cookies was $256. Now it is on sale under a promotion of “buy 3 get 1 free”. If Peter wants to buy 4 bags of cookies, how much should he pay?

Students' work


. Ada has $230 and has $30 less than Ken. Ken uses his money to buy 4 toys at the same price. How much is each of the toys?

Bar model:

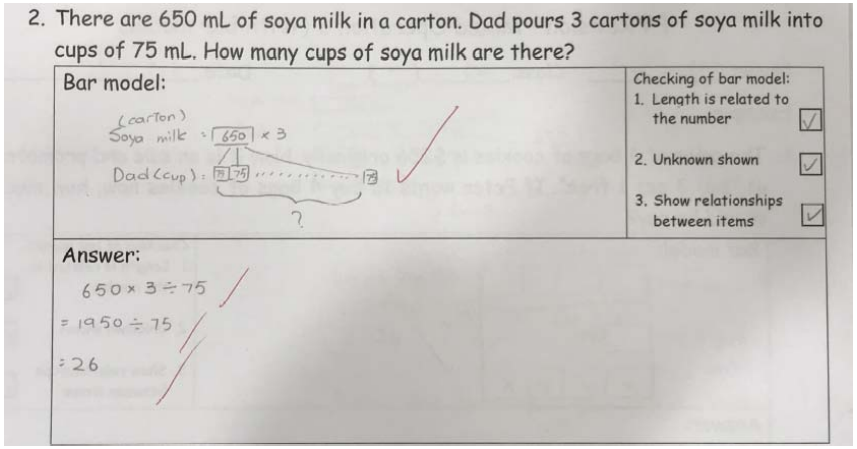
Ada = $230
Ken = $230 + $30
230 + 30
Ken buy 4 toys

Checking of bar model:
1. Length is related to the number ✓
2. Unknown shown ✓
3. Show relationships between items ✓

Answer: (230+30)÷4
= 260÷4
= 65

Each of the toys costs $65.

Student's work sample from lesson 3


2. There are 650 mL of soya milk in a carton. Dad pours 3 cartons of soya milk into cups of 75 mL. How many cups of soya milk are there?

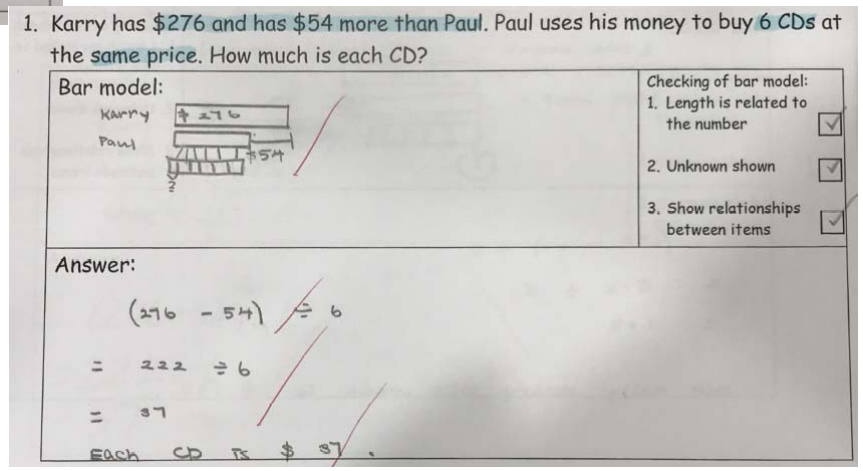
Bar model:

(carton) Soya milk : 650 × 3
Dad (cup) : 75 75 75
?

Checking of bar model:
1. Length is related to the number ✓
2. Unknown shown ✓
3. Show relationships between items ✓

Answer:
650 × 3 ÷ 75
= 1950 ÷ 75
= 26

Student's work sample from lesson 5


1. Karry has $276 and has $54 more than Paul. Paul uses his money to buy 6 CDs at the same price. How much is each CD?

Bar model:

Karry $276
Paul $54
?

Checking of bar model:
1. Length is related to the number ✓
2. Unknown shown ✓
3. Show relationships between items ✓

Answer:
(276 − 54) ÷ 6
= 222 ÷ 6
= 37
Each CD is $37.

Student's work sample from lesson 4

Findings

	Worksheet (3rd lesson)	Worksheet (4th lesson)	Worksheet (5th lesson)
No. of students	23 (1 absentee)	24	24
Mean	64.13%	79.17%	93.75%
SD	25.35%	25.69%	10.83%

Observation: Increasing mean and reducing standard deviation

Findings

Students' marks were on an upward trend, denoting continuous improvement, so repeated practice of using the bar model method is recommended. This helps students to be familiar with the use of bar model and form a habit to use the bar model method as an effective tool to analyze and solve word problems.

Using bar model is an important step to complete the missing link, helping them to find the relations among key words and to translate the situation into the mathematical language.

Questions about students' action
(after using the bar model method)

Question number	Questions	True	False
1	I will put down any answer just to finish a problem.	47.8%	52.2%
2	I will try almost any problem.	87%	13%
3	I will work a long time on a problem.	43.5%	56.5%
4	I need someone to help me work on problems.	52.2%	47.8%
5	I will keep working on a problem until I get it right.	82.6%	17.4%

Responses to the questions on students' action

Responses to questions 2 and 5 indicated that most of the students (>80%) would keep working on a question until an answer was obtained. This reflected that they became more willing to solve questions after learning the bar model method.

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Responses to the questions on students' action

The pattern of responses to question 4 however showed that more than 60% of them thought that they needed help when they worked on problems. This reflected that they needed more facilitation on using the new tools.

Questions about on students' attitudes

Question number	Questions	True	False
1	It is no fun to try to solve problems.	30.4%	69.6%
2	When I do not get the right answer right away, I give up.	30.4%	69.6%
3	I like to try hard problems.	82.6%	17.4%
4	There are some problems I will just not try.	43.5%	56.5%
5	I do not like to try problems that are hard to understand.	39.1%	60.9%
6	I like to try to solve problems.	78.3%	21.7%
7	I give up on problems right away.	43.5%	56.5%

Responses to the questions on students' attitude

Questions 3 and 6 showed that most of the students (about 80%) liked to try to solve hard problems. This reflected a positive attitude towards mathematics problem solving in the beginning stage.

Students would not turn away at o nce when they faced mathematics problems.

Questions about on students' attitudes

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7	I give up on problems right away.	43.5%	56.5%

Responses to the questions on students' attitude

The responses to questions 4 and 7 also indicated they would not give up right away. This pattern was in contrary to the responses to questions 3 and 6. Further research is needed to achieve a more accurate conclusion.

Questions about students' self-confidence

Question number	Questions	True	False
1	My ideas about how to solve problems are not as good as other students' ideas.	82.6%	17.4%
2	I can only do problems everyone else can do.	52.2%	47.8%
3	I am sure I can solve most problems.	91.3%	8.7%
4	I can solve most hard problems.	65.2%	34.8%
5	Most problems are too hard for me to solve.	47.8%	52.2%
6	I am a good problem solver.	47.8%	52.2%

Responses to the questions on students' attitude

As indicated in the responses to question 1, most of the students (>80%) thought that they were not confident in the ideas that they had used. More than half of them (>50%) thought that they were not better than others (question 2).

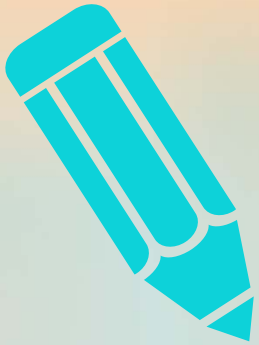
Responses to questions 3 and 4 nevertheless suggested that most of them were sure they could solve all the problems (>90%) including the more difficult ones (>60%). After learning the skills of the bar model, they became more confident in themselves.

Conclusion

1. The result of the WS suggested that students' abilities towards solving word problems increased after using bar model.

2. The result of the questionnaires suggested that the bar model method had positive influence towards students actions, attitudes and self-confidence.

Methodology (Qualitative)



Six students in the class were selected to participate in face-to-face interviews.

The six students were asked to describe their feelings on the use of the bar model during the study.

The aim was to find out what was the most impressive or important effect of the bar model.

Questions used in interview

Questions
1. Before using bar model, did you find it hard to set up the horizontal from of the word problem? Why?
2. Can you describe the method you used to solve the word problem, before you learn the bar model method?
3. Which method do you think is better? Why?
4. Do you think that the bar model is helpful when you analyse the word problems? Why?
5. Do you think bar model give you more confidence in solving word problems? Why?

Teacher-student interview questions

Findings

1. Before using bar model, did you find it hard to set up the horizontal from of the word problem? Why?

For question 1, 4 out of 6 students said that setting up the horizontal form was hard, as there was a lot of information given in the questions. It was difficult to find the linkage between the information given, and thus they could not translate them to the mathematical language (the horizontal form).

Only 2 out of 6 students said that setting up the horizontal form was easy as they had attempted some similar questions before.

They found it difficult to handle some unfamiliar problems and to describe the word problems using the mathematical language.

Findings

2. Can you describe the method you used to solve the word problem, before you learn the bar model method?

With respect to question 2, all the students mentioned “read the keywords”. This indicated that they had already learnt the method to handle word problems in earlier stages.

However, together with their responses to question one, the traditional “keyword” method did not appear sufficient for them to solve unfamiliar word problems.

The missing link would be that they could not find the relations among the keywords and did not know how to solve the problems mathematically.

Findings

3. Which method do you think is better? Why?
4. Do you think that the bar model is helpful when you analyse the word

For question 3 and 4, all of the students agreed that the bar model method was useful, reflected by some of the comments made by the students as follows:

Student A: It (the bar model) provides a way to visually describe the contents. It is easier to change the contents into mathematical language. It can also show the relationship of the information easily.

Student B: It helps to **show the relationship** of numbers by letting me **see it**.

Student C: If the question is complicated or not familiar, the bar model is helpful. It can help me to break down questions, visualise and find the relationships among the numbers.

Student D: It helps me to visualise the whole questions so that I can find the relationships among the numbers more easily.

Student E: It helps me to understand and analyse the problem.

Student F: With the bars (used in the bar model method), it is much easier to understand the relationships as it visualises the relationships.

Findings

5. Do you think bar model give you more confidence in solving word problems? Why?

For question 5, all the students agreed that the bar model method increased their confidence in solving word problems. The followings are some of the students' comments:

Student A: The bar model helps me to understand the content more easily and it helps me to describe the relations among the contents.

Student B: Every time I use the bar model method (in handling difficult problems or checking), the correct answer can be found.

Student C: It (the bar model method) can help to break down the content in the question, visualising and finding the relationships among the numbers.

Student D: It (the bar model method) can help to break down the content in the question and make the questions easier to understand.

Student E: It (the bar model) can help me to break down and analyse the question.

Student F: It (the bar model) makes the question easier to understand. It also helps to break down a complicated question.

Limitation

1. In this research, only one class of students was involved. A larger scale study should be conducted in the future with more classes or forms so that the representativeness of the findings can be improved.

2. Further improvements in research could be achieved if the study was conducted for a longer period of time in a spiral model. Pedagogy or curriculum for bar model method could be formulated and evaluated continuously and regularly.

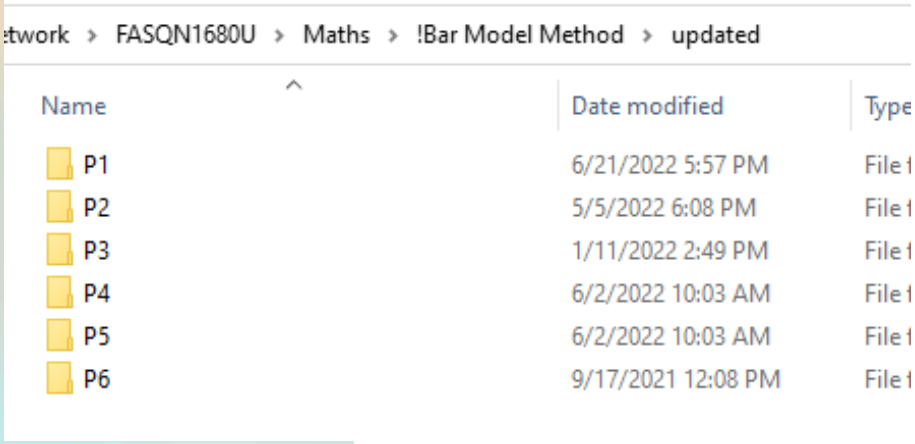
Limitation

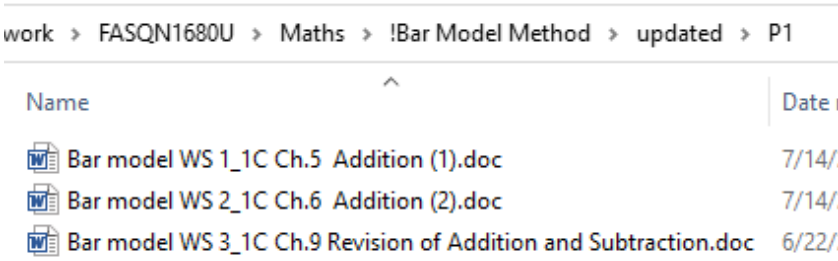
3. Tracing of students' results can be useful in finding out the long term effects of the bar model method on students.
   In this study, short-term spiral teaching was conducted to enhance students' habit or performance, but tracing students' habit or attitude towards problem solving should also be carried out in order to find out if the habit of using the bar model method as a tool has been formed.

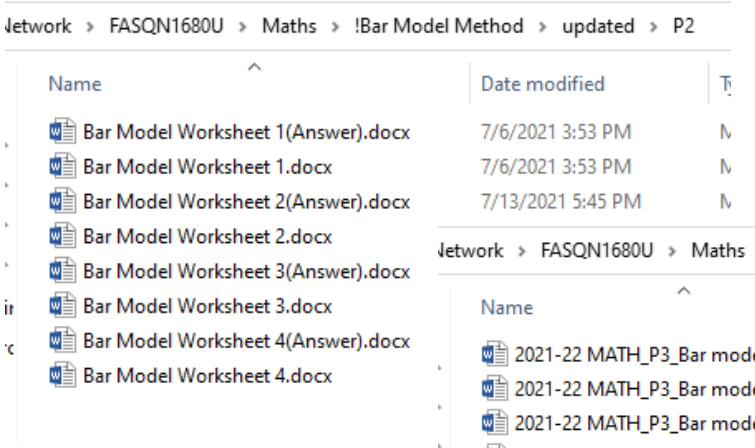
4. A more systematic guideline on using the bar model method should also be introduced. Student's performance in each single step of drawing bar models should be investigated in order to have an in-depth study on the effectiveness of the bar model method. This aims to enhance the structure of the bar model and to improve the effectiveness.

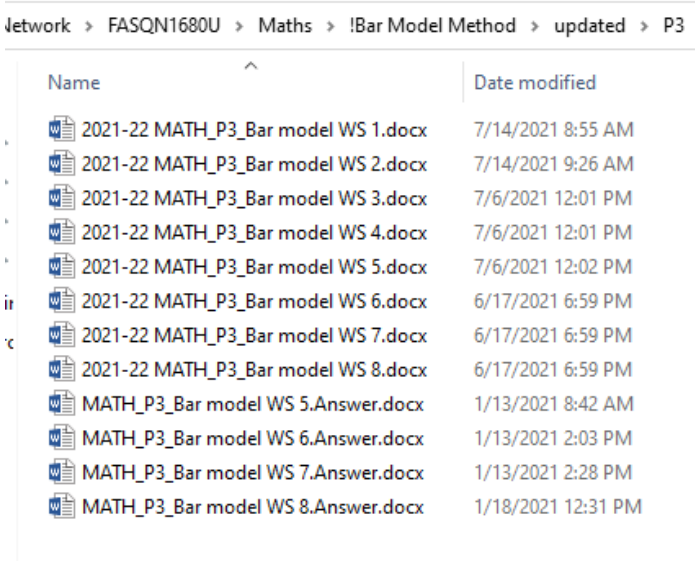
Follow up works after the action research

Follow up works after the action research









Thank you

Q&A