Speaker

Enhancing Mathematics Assessment with Validated Resources

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An Institute of NANYANG TECHNOLOGICAL UNIVERSITY

Overview 1

SMAPP Project

- Singapore Mathematics Assessment and Pedagogy Project
- Sep 2008 – Dec 2012
- RD & I (Research, Development and Innovation) project; new assessment
- Funding: Centre for Research in Pedagogy and Practice (CRPP), National Institute of Education, Nanyang Technological University

Wong (APEAC, 12/9/13)

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Team Members

1. Wong Khoon Yoong (PI, from Nov 2010)
2. Zhao Dongsheng (Co-PI)
3. Cheang Wai Kwong
4. Fan Lianghuo (PI, 2008 to Oct 2010)
5. Lee Peng Yee
6. Quek Khiok Seng
7. So Hyo Jeong
8. Teo Beng Chong
9. Teo Kok Ming
10. Yen Yeen Peng (CPDD, MOE)
11. Yvonne Ng Qiu Ting (PM) & Others who left project

Strong participation of Mathematicians; ensure mathematical rigour

Wong (APEAC, 12/9/13)

Overview 3

Participants

	Schools	Teachers	Classes (S1 E)	Students
Partial participation	9	59	90	3074
Main study (2011) • 2 extended tasks • Everyday maths • Attitude	I: 4 C: 4	I: 16 C: 14	I: 11 C: 14	I: 406 C: 527

S1 E: Secondary 1 (Express); Grade 7; average and mixed ability

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Main Publication

- Not for sale; given free to all Singapore secondary schools
- E-book (reading): http://hdl.handle.net/10497/11492

Real-Life Mathematics Tasks
A Singapore Experience

Singapore Mathematics Assessment and Pedagogy Project
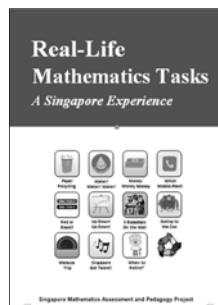
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Disclaimer

The views expressed at this lecture are those of the author's and do not necessarily represent the views of the

- Centre for Research in Pedagogy and Practice (CRPP)
- National Institute of Education (NIE)
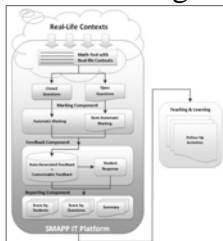- Singapore Ministry of Education (MOE)

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Overview

1. Maths disciplinary tasks
2. IT-based assessment system
3. Attitudes toward learning maths

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Real-Life Contexts

- Singapore Maths Curriculum (2013): stronger emphasis on "solve real-world problems"; "connect mathematics that they have learnt to the real world"
- Help students gain knowledge about the world, while honing their maths skills
- Aligned with international trends

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OECD: Mathematical Literacy

- An individual's capacity
- to identify and understand the role that mathematics plays in the world,
- to make well-founded judgements and
- to use and engage with mathematics in ways that
- meet the needs of that individual's life as a constructive, concerned and reflective citizen

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Design Framework (2009)
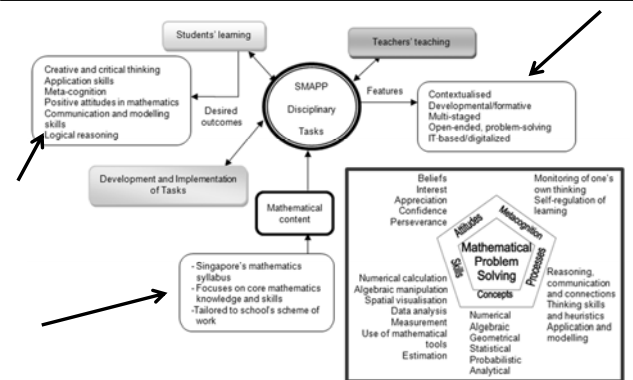
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Two Types of SMAPP Tasks

a) 11 extended tasks, multiple competencies (computation, reasoning, explanation), mathematically rigorous; take about one hour to complete; learning experiences; delivered through IT system

b) 10 short paper-pencil problems (Everyday Maths Items), similar to PISA; exercises or tests

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Extended Tasks: Principles

a) Links to real life scenario
b) Real and relevant data
c) Curriculum connection
d) Multiple competencies and content knowledge assessment
e) Experience enriching
f) Scaled levels of difficulties

- Zhao, D.S., Cheang, W. K., Teo, K. M., & Lee, P. Y. (2011). Some principles and guidelines for designing mathematical disciplinary tasks for Singapore schools. In J. Clark, B. Kissane, J. Mousley, T. Spencer & S. Thorton (Eds.), *Mathematics: Traditions and (new) practices: Proceedings of the AAMT-MERGA conference* (pp. 1107-1115). Adelaide: Australian Association of Mathematics Teachers.

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11 Extended Tasks: IT based

No.	Task Titles	Topics
1	Paper Recycling	Arithmetic
2	Red or Black?	Arithmetic, Algebra
3	Malacca Trip	Rate, Speed, Algebra, Inequalities
4	Water Water Water!	Mensuration, Statistics
5	Up Down Up Down!!	Statistics
6	Singapore Got Talent	Geometry
7	Money Money Money	Linear Graphs
8	Three Rockstars on the Wall	Angles, Parallel Lines
9*	When to Retire?	Numbers, Algebra
10*	Which Mobile Plan?	Statistics, Percentages
11*	Outing to the Zoo	Data handling, Algebra

* Based on teachers' contributions in November 2010

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2 Extended Tasks: Findings

Tasks	Max	Female	Male	Overall	%
Paper Recycling	33	20.8 (273)	20.5 (86)	20.8 (364)	63%
Red or Black?	31	16.4 (287)	16.5 (90)	16.2 (383)	52%

- Successful with routine questions
- Weak in unfamiliar units, multi-step questions, giving reasons, explain own ideas
- Cheang, Teo, Zhao, http://repository.nie.edu.sg/jspui/handle/10497/8158

Decibel Question: Try It

The loudness of sound is measured in decibels (dB). Noise from heavy traffic is about 85 dB and this can cause hearing damage if one is exposed to it for 8 hours or more. For every 3 dB over 85 dB, the exposure time before damage occurs is decreased by half.

(a) If the noise is 88 dB, what is the exposure time before damage occurs?

(b) John likes to listen to his music using ear-plugs at high volume of 100 dB. How long could he do this before damage occurs?
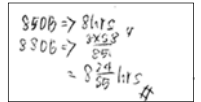

Decibel Question: Results

a) Correct answer with working (27%); Correct answer, no working (10%); Wrong proportional reasoning (4%)

b) Full mark (21%); Partial (24.5 %); Wrong (45%) Popular method: stepwise decrease

- 39%: relevant to daily life (most relevant and challenging)

Easiest: Sale (72%)

A particular item costs $6. Shop X advertises, "buy four items for the price of three".

(a) How much does a customer have to pay for 4 such items in shop X? (0.98/1)

(b) What is the percentage discount for the customer who buys 4 such items from shop X? (1.61/2)

(c) Another shop Y offers, "buy three at the regular price and pay 50% for the fourth item." Shop Z offers a voucher of 10% on the total amount paid. Your parents wish to buy 4 such items.

Out of these 3 shops (X, Y, and Z), which shop gives the best deal? (3.52/5)

(d) Other than the amount you have to pay, what other reasons would you give to your parents to support your choice? (0.34/1)

Everyday Maths Items: Admin

- 5 items administered in March 2011 as "pre" test
- 5 items in Sept 2011 as "post" test
- But not parallel items
- Pre-post labels for identification only

Everyday Maths Items: Findings

$n \approx 814$
S1E

Re-arranged in order of facility

Question	Context (Topic)	Facility Index
1	Sale (Percentage, discount)	71.7
2	Tourism (Interpretation of table and pie chart, rate)	64.9
3	Kool Biscuits: Reduced fat (Percentage)	61.8
4	Population (Interpretation of table, significant figures, rate)	57.4
5	Types of fires (Interpretation of table, percentage change)	54.6
6	Decibels (Four operations, rate)	40.8
7	Earthquake (Powers of 2)	36.6
8	Mobile plan (Rate, line graph)	35.5
9*	Hokkien char mee (Interpretation of chart, percentage)	26.1
10*	Math Olympiad (Line graph, bar graph, misuse of graphs)	22.2

Everyday Maths Items: Groups

Group	Male	Female	Overall	Sample Size
Intervention	38.0 (11.4)	37.9 (12.4)	38.0 (12.1)	327
Comparison	37.6 (11.4)	42.6 (12.5)	40.6 (12.3)	487
Overall	37.7 (11.4)	40.5 (12.6)	39.5 (12.3)	
Sample Size	284	530		814

Everyday Maths Items: Observations

- Lack of experience with real-life contexts
- Inappropriate use of maths skills
- Amount of reading
- Maths beyond S1 level; more suitable for upper secondary
- Student perceptions: neutral in terms of interest, relevance; a bit challenging, less confident

IT-Based Assessment: Trends

- International trend: Develop IT-based assessment of construct-response items; efficiency and commercial, technical issues
- Singapore: *Math Explorer* can grade multi-line steps; defunct
- SMAPP: IT-based assessment based on pedagogy, assessment for learning

Assessment for Learning (*AfL*)

- Provide informative feedback to students to enhance their performance (Sadler, Black, Wiliam, Hattie, etc.)
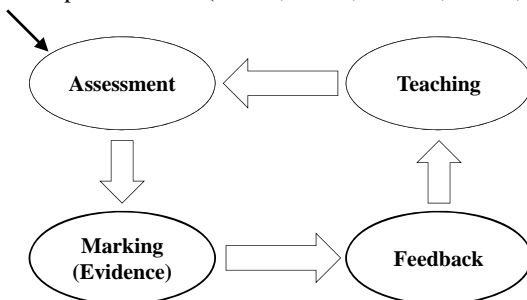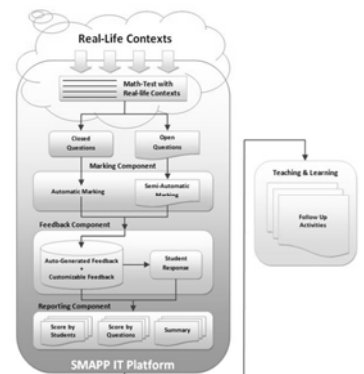
IT Platform with *AfL* Features

1. Deliver tasks (extended)
2. Capture answers; closed & open questions
3. Automatic & Semi-automatic marking
4. Customisable feedback
5. Student responses to online feedback (*)
6. Reports by questions, students, class
7. Follow up activities (*)

(*) Not successful

Delivery & Capture

Question : Q1e | Mark(s) : 3 ✓ Answer saved!

There are 1,200 students in Shamila's school. It is estimated that each student uses about 3 reams of A4 paper per year (for notes, test and exam papers, etc.).

If the school uses only recycled paper, how many trees can be saved each year? (Recall that 1 tonne of paper ≈ 17 trees)

(i) Amount of paper used

= 3 × 1200 × 2.5 kg = 9000 kg

(ii) 9000 / 1000 × 17 = 153 trees

Save

Capture of student answers

- Online calculator
- Entry of mathematical symbols and expressions
- Simple animations

Marking and Feedback

Semi-automatic marking

Correct answer

Question

Customisable feedback

Automatic & Semi-automatic Marking

- *Closed* questions: Automatic marking
  - Expedite marking; alleviate teacher marking workload
  - Consistency in marking
- *Open* questions, workings: Semi-automatic marking
  - Teacher selects score from given scheme
  - Recommend teachers mark by questions to note different student solutions
  - Expedite marking; alleviate teacher marking workload
  - Consistency in marking

Customisable Feedback

- Every question is tagged to several feedback comments
- Correct answer: Gives general praise and reiterates the correct procedure
- Wrong or incomplete answer: Hints on how to proceed further

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Teacher Can Add Feedback

- Teachers can enter own feedback comments
- Comments can be saved and shared within school

Students' Responses to Feedback

- After marking and entering feedback: Students asked to reflect on teacher feedback
- 3 choices of student responses; encourage metacognition and reflection
- Teachers to follow up

Your method for finding the total mass of paper used is wrong. Multiply 3 reams and the total number of students to find the number of reams. Then multiply 2.5 kg (mass of one ream) to get the total mass.

- (1) Now, I understand.
- (2) I still do not understand, so I will discuss with my teacher.
- (3) I still do not understand, so I will discuss with my friends.

Submit

Report System

- By students, questions, class; mean and frequency
- Can be downloaded into EXCEL format

Paper Recycling: Teacher

- Responses from Teachers ($n = 10$).

Questions	Mean	SD
Appreciate the connections of mathematics with real life situations.	4.20	0.92
It is easy to add my own feedback to the system.	3.75	1.04
By focussing on open-ended questions, I know more about my students' thinking, e.g., different methods used.	3.44	1.13
I prefer this system to manual marking.	3.33	1.12

Paper Recycling: Students

- Online survey; $n = 99$ (2011)
- 5-point Likert Scale

Questions	Mean	SD
I find the scenario provided in the task realistic.	3.70	1.00
I prefer to do this task on paper rather than doing it using the IT platform.	3.49	1.18
I have no difficulty following the instructions given.	3.43	1.22
I find the scenario provided in the task interesting.	3.34	1.14
I gained some new mathematical knowledge/skills by working on the task.	3.12	1.04
The IT platform is helpful for me to do this task.	3.02	1.55

Paper Recycling: Student Interviews

- Some preferred to work on paper rather than online; need to familiarise students with IT-based assessment; future trend?
- Some students aware of benefits of IT: *lessen time, easy to search for information, do not waste paper, can erase answer easily*
- Knowledge about recycling: *Ah…save earth, like save trees then the trees can produce oxygen for us and that it can reverse the effects of global warming*

Attitudes Toward Learning Maths

- Curriculum: Desirable outcome; one factor for effective problem solving (Singapore Maths Curriculum)
- Learning : Positive, significant but moderate correlate (about .3) with achievement; US National Mathematics Advisory Panel (2008): "Children's goals and beliefs about learning are related to their mathematics performance" (p. xx)
- Teaching : Ways to improve attitudes
- Research: Not necessarily causal with achievement; design and validation of instruments; define construct

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ALMQ: Development

- 2010: 57 items. 9-point Likert; greater variation, but students may not be able to make fine distinctions
- Exploratory factor analysis and confirmatory factor analysis
- 2011: 24 items; 6 constructs, 4 items per construct:
  a) Check solutions
  b) Confidence
  c) Enjoyment
  d) Use of IT
  e) Multiple solutions
  f) Usefulness
- Cronbach's alphas acceptable, 0.63 to 0.90

ALMQ: Your Score?

- 9 = Agree totally; 1 = Disagree totally
- Negative items: 10 – your point

Scales	Items
Check solutions	1, 7, 13*, 19
Confidence	2, 8, 14, 20*
Enjoyment	3, 9*, 15, 21
Use of IT	4*, 10, 16, 22
Multiple solutions	5*, 11, 17, 23
Usefulness	6, 12, 18*, 24

ALMQ: Results

- Less positive over time from March to Oct 2011

Group		Male	Female	Overall	Sample Size
Intervention	March	6.37 (1.08)	6.02 (1.04)	6.11 (1.06)	365
	Sept	5.78 (1.22)	5.65 (1.07)	5.69 (1.11)	352
Comparison	March	6.28 (1.23)	6.12 (1.00)	6.18 (1.10)	483
	Sept	5.78 (1.26)	5.54 (1.11)	5.64 (1.18)	495
Overall	March	6.31 (1.18)	6.07 (1.02)	6.15 (1.08)	
	Sept	5.78 (1.24)	5.59 (1.09)	5.66 (1.15)	
Sample Size	March	287	561		848
	Sept	296	551		847

Everyday Maths vs. ALMQ (Post)

Attitude	Everyday (n ≈ 800)	Paper (n ≈ 350)	Red? (n ≈ 350)
Overall	.290	.296	.299
Check solutions	.281	.266	.274
Confidence	.272	.260	.272
Enjoyment	.231	.194	.224
Use of IT	.032	.103	.107
Multiple solutions	.178	.193	.210
Usefulness	.273	.291	.232

- "Expected" values for 4 scales
- Not familiar (IT, Multiple solutions), low correlations

Teacher Professional Development

- Important part of project
1. 8 teacher workshops for all participating schools
2. 3 mini workshops for individual schools
3. School meetings to discuss findings
- Use of SMAPP IT system
- Assessment literacy
- Task design; teachers created 3 extended tasks
- Data analysis and interpret findings

Number of Trees to be saved

1.

(a) The length and breadth of an A0 paper are 0.841 m and 1.189 m respectively. Which of the following expressions is correct to obtain the area of an A0 paper? [1]

(1) $(0.841 + 1.189) \times 2$
(2) 0.841×1.189
(3) $1.189 \div 0.841$
(4) $1.189 - 0.841$ (   )

(b) An A1 paper is obtained by folding an A0 paper into two equal halves lengthwise.
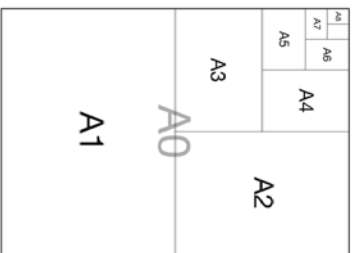
Similarly, an A2 paper is obtained by folding an A1 paper into two equal halves lengthwise.

Table 1 shows the estimated area of the "A" series paper size and the number of sheets of paper that can be obtained from an A0 paper.

Fill in the blanks with the correct answers. [4]

Table 1

"A" series paper size

Paper Size	Estimated Area (m²)	Number of sheets of paper that can be obtained from an A0 paper
A0	1	1
A1	0.5	2
A2	0.25	4
A3		8
A4	0.0625	
A5		32
A6	0.015625	
A7	0.0078125	128
A8	0.00390625	256

(c) i. Based on your answer to the area of an A5 paper, find its estimated area in **square centimetres**. ($1\ m^2 = 10\ 000\ cm^2$). [1]

ii. Find the number of sheets of **A5 paper** that can be obtained from a sheet of **A2 paper.** [1]

(d) Looking at the packaging of the printing paper, Shamila sees "80 g/m²" (80 grams per square metre) printed on it.

i. What is the mass of one sheet of A4 paper? [2]

ii. One ream of paper contains 500 sheets of printing paper. What is the total mass of one ream of A4 paper (excluding the mass of the packaging)? Give your answer in kg. [2]

(e) There are 1200 students in Shamila's school. It is estimated that each student uses about 3 reams of A4 paper per year (for notes, test and exam papers, etc.).

If the school uses only recycled paper, how many trees can be saved each year? (Recall that 1 tonne of paper ≈ 17 trees.) [3]

(f) If the school uses a lighter type of paper (70 g/m² instead of 80 g/m²), how many **more** trees can be saved each year? Give your answer as a whole number. [2]

Benefits of using Recycled paper

Shamila wants to make a poster to present some of the facts and figures on the benefits of recycling paper and using recycled paper. Besides the number of trees that can be saved, she plans to include other information on the benefits to the environment if the school converts to recycled paper. You are approached to help her solve the rest of the problems.

2.

(a) By searching for "advantages of recycling paper" on a search engine, find and write down 2 benefits of recycling paper. [2]

(b) It is estimated that each mature tree can absorb 16 kg of carbon dioxide and produce 10 kg of oxygen each year. If the school saves 150 trees per year by using only recycled paper,

i. how much carbon dioxide could have been absorbed by those 150 trees per year? [1]

ii. how much oxygen could have been produced by those 150 trees per year? [1]

(c) On average, a car emits about 0.16 kg of carbon dioxide for every kilometre travelled (http://www.carpages.co.uk/co2). If it emits the same amount of carbon dioxide as found in **(b)(i)**, how far has it travelled in km? [2]

Save Water!

3.

(a) Fill in the blanks based on the information from the poster below.

Facts about recycling:

"Every tonne of paper recycled can save 17 trees, 1438 litres of oil and 26 495 litres of water. People are urged to recycle!"

A wall poster at Changi Airport states that every tonne of paper recycled can save _____ litres of water and _____ litres of oil. [2]

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THE SMAPP PROJECT TEAM

Singapore Mathematics Assessment and Pedagogy Project

Student Questionnaire

School	Class	Name	Index Number	Gender
Date				

Dear students: The purpose of this survey is to find out how Secondary One students think and feel about mathematics. Your responses will help us understand students like you better. All responses will be kept strictly confidential. Please answer **ALL** the questions as best as you can. For each question, please tick (√) your answer. There is no correct or wrong answer to each question. Thank you for your cooperation.

Please take note of the following scale:

1 - Disagree totally   2 - Disagree a lot   3 - Disagree   4 - Disagree a little
5 - Neither Disagree nor agree   6 - Agree a little   7 - Agree   8 - Agree a lot
9 - Agree totally

Attitudes	Disagree Totally								Agree Totally
	1	2	3	4	5	6	7	8	9
1. When I know I have made a mistake in solving a problem, I will try to find out why.	O	O	O	O	O	O	O	O	O
2. I am good at using mathematics to solve real-life problems.	O	O	O	O	O	O	O	O	O
3. I enjoy doing mathematics.	O	O	O	O	O	O	O	O	O
4. I do not like to use the computer to learn mathematics.	O	O	O	O	O	O	O	O	O
5. I do not like to think of other ways to solve the same problem.	O	O	O	O	O	O	O	O	O
6. Mathematics is important.	O	O	O	O	O	O	O	O	O
7. After I have solved a problem, I will go through the solution again and check if I have made any mistakes.	O	O	O	O	O	O	O	O	O
8. I am confident in solving mathematics problems.	O	O	O	O	O	O	O	O	O
9. I find mathematics boring.	O	O	O	O	O	O	O	O	O
10. I can learn mathematics from playing computer games.	O	O	O	O	O	O	O	O	O

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Attitudes	Disagree Totally								Agree Totally
	1	2	3	4	5	6	7	8	9
11. I often figure out different ways to solve mathematics problems.	O	O	O	O	O	O	O	O	O
12. I think mathematics is useful in solving real world problems.	O	O	O	O	O	O	O	O	O
13. Once I have worked out an answer to a problem, I do not check my answer.	O	O	O	O	O	O	O	O	O
14. I find mathematics easy.	O	O	O	O	O	O	O	O	O
15. Overall, I have good feelings about mathematics.	O	O	O	O	O	O	O	O	O
16. IT (Information Technology) has been helpful to my mathematics learning.	O	O	O	O	O	O	O	O	O
17. I try to understand the different solutions given by my classmates.	O	O	O	O	O	O	O	O	O
18. I think mathematics is useful only for tests.	O	O	O	O	O	O	O	O	O
19. After I have solved a problem, I will ask myself if the answer makes sense to the given problem.	O	O	O	O	O	O	O	O	O
20. I am not good at giving reasons in mathematics.	O	O	O	O	O	O	O	O	O
21. Solving mathematics problems is fun to me.	O	O	O	O	O	O	O	O	O
22. Mathematics software (e.g., graphing) helps me to learn mathematics.	O	O	O	O	O	O	O	O	O
23. After I have solved a problem, I will look for other methods to solve it.	O	O	O	O	O	O	O	O	O
24. Mathematics helps me to understand reports and advertisements about prices, sale, percentages etc.	O	O	O	O	O	O	O	O	O