Welcome

Enhancing Student Motivation in Mathematics

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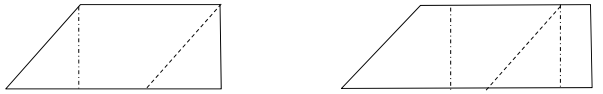
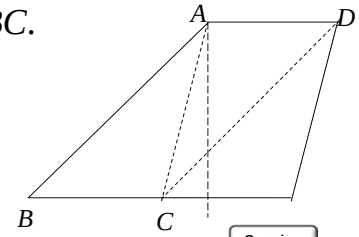
Bring These Materials

1. Writing paper, scissors, protractor, ruler.
2. Cut out these trapezium (make them bigger). Dotted lines are for folding; do not cut.



3. Make sure perpendicular from *A* "falls outside" the base *BC*.



Main Message

You can make a difference:
use
M_Crest
to get *every* student motivated.

Overview

1. How serious is lack of motivation?
2. What are some motivation constructs?
3. How to implement the M_Crest strategies?
4. How do I research motivation?

Motivation: A Problem?

- How serious is lack of motivation among your students?

1. Very serious; more than 70% of your students *not* engaged most of the time
2. Quite serious
3. Not serious
4. Not serious at all; more than 70% of your students are engaged most of the time

TIMSS 2011: S2

- International average: 10
- Singapore students "normal" with international average.

Like learning Math	Value Math	Confident in learning Math

Motivate: Meanings

- Latin: *movere*, to move.
- Reasons to move (act); needs.
- Teacher moves students to learn.
- Students move themselves to learn; more important.

Motivated "Adjectives"

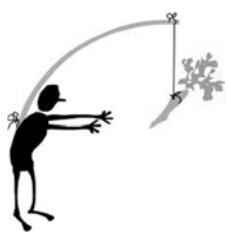
1. Think of students who are motivated to learn Math.
2. Jot down at least five adjectives. (Wait 2 min)

Four Types of Motivation

1.	Achievement (grades)	Parental expectations, kiasu
2.	Extrinsic (requirements)	Rewards, punishments; beyond own control, unrelated to tasks
3.	Intrinsic (experience)	Related to tasks; satisfaction, self-motivated, choice (?)
4.	Social (relationship)	Belonging, impress others (?)

Motivation → Engagement

Motivated → Engaged → Performance

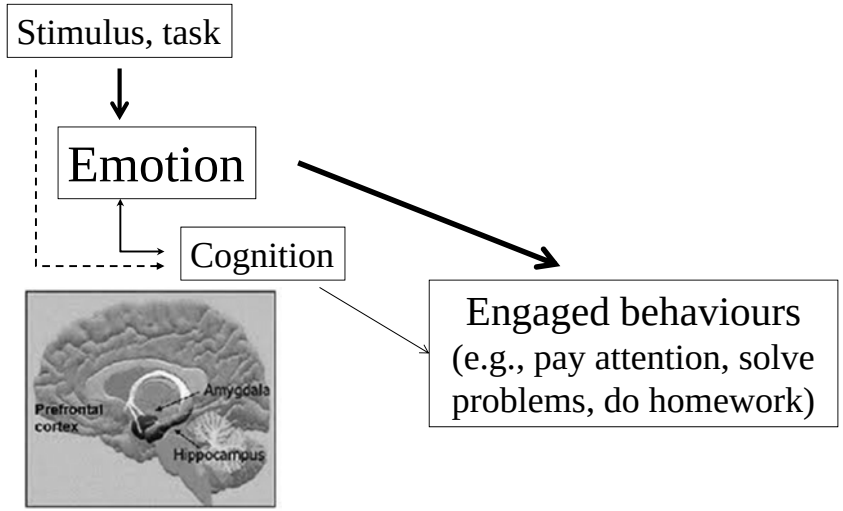


Four Types of Engagement

1.	Emotional		Will do; feel
2.	Cognitive		Can do; know
3.	Social		Do with others; belong
4.	Physical		Hand-on.

Assume that students have satisfied basic physiological needs.

Emotion Overrides Cognition



Demotivated "Adjectives"

1. Think of students who are not motivated to learn Math.
2. Jot down at least five adjectives.

Negative Experiences

Self-esteem (emotion)

Behaviour (repeated failure)

Straits Times, *Mind Your Body*, April 9, 2009, p. 7.

Sunday Times, 28 Sept 2003, p. 54.

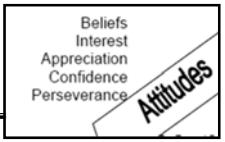
High Math Anxiety

- Smaller working memory span; cannot pay attention.
- Less resources for learning and performance; poor problem solving.
- Resort to rules rather than thinking.

Negative Trumps Positive

- Hattie (p. 48): demotivation more impactful than motivation.
- Not all students respond positively to motivating strategies (positive emotions).
- One negative incident (anxiety, fear, frustration, ignored) could "destroy" effects of motivating practices; last longer.
- Do no harm.

MOE: Attitude



- Making the learning of mathematics fun, meaningful and relevant goes a long way to inculcating positive attitudes towards the subject.
- Care and attention should be given to the design of learning activities, to build confidence in and develop appreciation for the subject. (p. 9)
- Emphasis on intrinsic motivation; provide rich learning experiences.

M_Crest: Your Ideas

- M_
- C_
- R_
- E_
- S_
- T_

Meaningful; Sense Making

- Explanations using words and symbols not engaging.
- Many rules, esp. algebra, not made meaningful to students, leading to
  - resort to memorisation, easily forgotten;
  - many misconceptions and errors;
  - demotivated.

Famous People

- Bertrand Russell (1872 – 1970): I was made to learn by heart: 'The square of the sum of two numbers is equal to the sum of their squares increased by twice their product'.

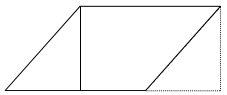
  I had not the vaguest idea of what this meant, and when I could not remember the words, my tutor threw the book at my head, which did not stimulate my intellect in any way. (1907)
- Carl Jung (1875 – 1961): I was so intimidated by my incomprehension (of algebra) that I did not dare to ask any questions.

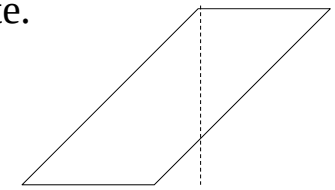
Concrete, Patterns, Visual

1. Concrete materials + explanations; multi-model representations.
2. Patterns, powerful link to prior learning; teachers should know when patterns "break down".
3. Visual representation and proofs.

Area of Parallelogram

- Standard justification; concrete.

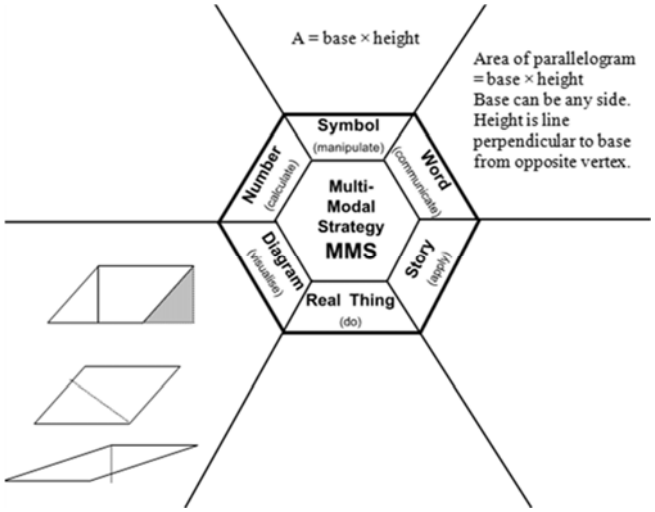




- Dienes' Variability principles.
- Rule still applies if perpendicular is "outside base"?
- How many proofs? Creative, differentiated.

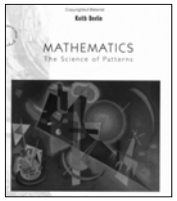
Multi-Modal: Parallelogram

Multi-modal Thinkboard: A holistic view!



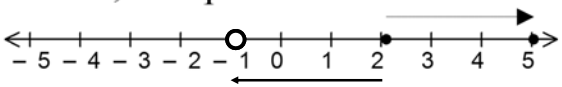
Maths = Study Patterns

- G.H. Hardy (*A Mathematician's Apology*, p. 84).
- *A mathematician, like a painter or a poet, is a maker of patterns.*
- *If his patterns are more permanent than theirs, it is because they are made with ideas.*
- Patterns → Abstract ideas → Structures



Patterns: Integers

- Addition, subtraction, compare.

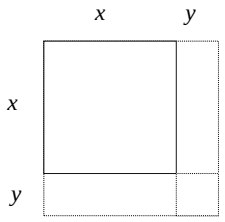


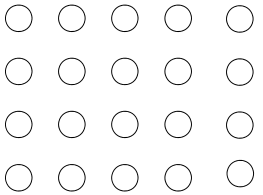
Operation	**Second number**	
	Positive	Negative
Addition		
Subtraction		

- Other topics: $a^0 = 1$; circle properties, etc.

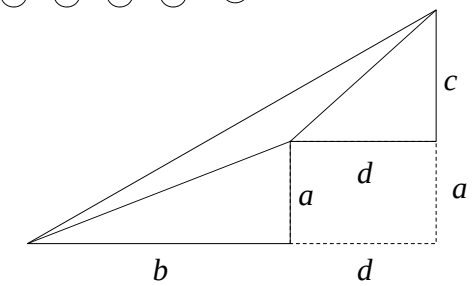
Make Sense via Diagrams

- What can you deduce from these pictures?





Nielsen (1993)



Teacher Clarity

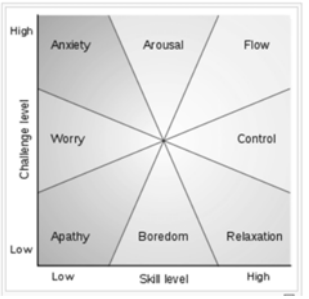
- Most desirable characteristics.
- Hattie (2009, p. 126): High effect size, *d* = 0.75, rank 8 among 138 influences.
- Students know what to do, meanings of what they are doing.

Confidence

- If meaningful, higher confidence.
- Build confidence: Begin with problems that *every* student can do. Graded problems.
- Students must feel that they are making progress, with suitable feedback, not necessarily solve it instantly.
- Ex: Sudoku: http://view.websudoku.com
- Celebrate *small* successes; then bigger success. Set realistic targets.

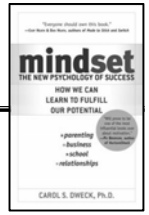
Csikszentmihalyi: Flow

- Flow, http://en.wikipedia.org/wiki/Mihaly_Csikszentmihalyi



- Match between skill and challenge.

Praise



- Use praise to instill confidence?
- Dweck: Mindset; p. 175.
- *You learned that so quickly! You're so smart!*
- Hidden message: *If I don't learnt something quickly, I'm not smart.*
- Test your student's mindset: http://mindsetonline.com/testyourmindset/step1.php

Praise: Ability vs. Effort

- Dweck: Mindset.

Types	Examples	Outcomes
Ability; fixed mindset	*So smart, like Einstein!*	Avoid challenging tasks; fear of failure; poor results, lie about scores.
Effort; growth mindset	*You have put in a lot of hard work.*	Willing to try hard problems, improve scores, more engaged.
No praise		Similar to fixed mindset.
Both?		

Dweck: Growth Messages

- Explain how learning "makes" brain grow.
- Send "growth" messages; easy to do.
- *Working on this new formula will s-t-r-e-t-c-h your brain.*
- *I am going to push you because I believe you will work h-a-r-d.*
- Write down some "growth" messages.

Add Reflection Questions

- After giving "growth" messages; add reflection questions:

1. Which parts of the problem did you enjoy the most?
2. What did you do when you were stuck? Did it work?

- Write down more "reflection" questions.

Mistakes

- Math different from arts and PE.
- Students think that mistakes in math should be avoided (marked wrong, zero mark), show that they are dumb.
- They do not believe "*learn from own mistakes*".
- Change their mindset? Learn from other's mistakes?

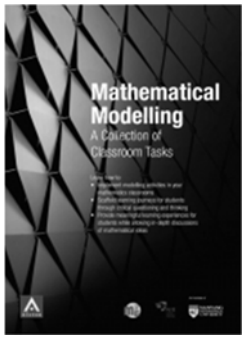
Praise Mistakes!

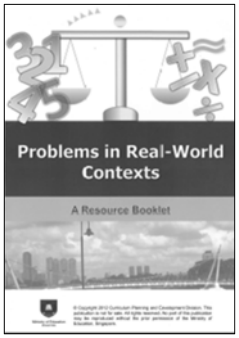
- Posamentier and Jaye (2006).
- Encouraging:
  - *Almost right! Try it again!*
  - *Good idea, try another direction!*
  - *I am afraid this is wrong; if you think harder, you will certainly get the right answer!*
- Neutral: "It's not right!"; "There is a mistake!".
- Anxiety-causing: "All wrong! Pay attention!"

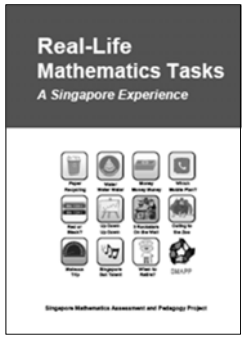
Relevance: Applications

1. Familiar contexts; discount, currency exchanges, etc.
2. Unfamiliar contexts; new knowledge; e.g., decibel; real data; National Education; maths trail.
3. Mathematical lens; inquiry mind; spot errors in media.
4. Applications to other math topics and subjects, e.g., radioactive decay.
5. "Career" motivation; preparation for future career; too distant.

4 Resources







- CSIRO: http://www.csiro.au/resources/Maths-by-Email.html

SMAPP: 2008 – 2012

- Singapore Mathematics Assessment and Pedagogy Project
- Two types of maths problems with real-life contexts: Extended; "Standard".
- Enhance knowledge of real-life contexts.
- Secondary schools: given 3 copies, e-resources.
- E-book: http://hdl.handle.net/10497/11492

Extended Tasks

- Delivered through IT platform.

Task Titles	Topics
Paper Recycling	Arithmetic sample
Red or Black	Arithmetic, Algebra
Malacca Trip	Rate, Speed, Algebra, Inequalities
Water Water Water!	Mensuration, Statistics
Up Down Up Down!!	Statistics
Singapore Got Talent	Geometry
Money Money Money	Linear Graphs
Three Rockstars on the Wall	Angles, Parallel Lines
When to Retire?	Numbers, Algebra
Which Mobile Plan?	Statistics, Percentages
Outing to the Zoo	Data handling, Algebra

"Standard" Tasks

- Paper-and-pencil; can be used in exam.
- 870 S1 Express students took the tests.

Q.	Context (Topic)	Facility Index (Mean as a % of Max Score)
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)	34.9
9	Hokkien char mee (Interpretation of chart, percentage)	26.1
10	Math Olympiad (Line graph, bar graph, misuse of graphs)	22.2

Decibel #1

- 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?
- Percentage correct, S1 Express?

Decibel #2

- (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?
- Percentage correct, S1 Express?
- Full mark:

- Popular method: stepwise decrease.
- 39% said relevant to life ($n \approx 870$).

Decibel: Exponential

- An increase of 10 dB corresponds to a 10-fold increase in sound intensity.

Loudness, L (dB)	0	10	20	30
Intensity, I (Wm^{-2})	I_0			

- Express I in terms of L and I_0.
- Find loudness of common events.
- Pose some questions.

Spot Errors: Food

Error?

Health Screening

Test result	Have disease	
	Yes	No
Positive		
Negative		

- Have disease, probability of positive test = .95
- No disease, probability of negative test = .94
- Probability of disease in population = .005
- What is the probability that a person has the disease given a positive test? Make a guess.

Enjoy, Curious, Fun

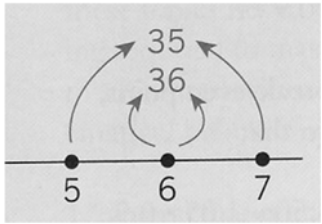
- Young children are innately curious; “why?” questions.
- Lose curiosity with age.
- Lillian Weber: Children begin school with an exclamation point (!) and a question mark (?);
- too often they leave as a plain period (.)
- Reverse the trend.

Enjoy: Strategies

1. Add surprise, unexpected, curious etc. to "standard" results; re-ignite your sense of curiosity.
2. Unusual situations, puzzles, games, brain teasers, magic, competitions, recreational topics, etc.
3. Your math journey.
4. Stories about mathematicians.
5. Fictions, movies, humour, etc.
6. Your enthusiasm counts; enjoy conducting these activities in lessons.

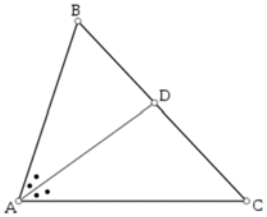
Standard Problems

- Is this surprising? Extend.



- Is Pythagoras' Theorem surprising?
- *C/d* = constant; compare and contrast.
- Activity. Coin experiment; enjoyable + meaningful.

Angle Bisector



Prove that:
BD: DC = AB: AC

- Before proving, make sense! Cut, fold, measure; two times.
- Re-write:

Discount greater than 100%

- Shangri-La (2009): Age-based discount.
- Discount more than 100%?

.

Enjoy Singing Maths

- Sing it! (St Margaret secondary school, The Straits Times, November 3, 2003, p. H9)

Gauss, Descartes, Pascal

- Gauss: outwit teacher; 1 + 2 + 3 + … + 100.
- Descartes: did math when sick; Cartesian coordinates.
- Pascal: compassionate; took in homeless family; “When we read too fast or too slowly, we understand nothing.”

Ramanujan (1887 – 1920)

- When young, worked out proofs on his own, independent of published work (not available to him).
- “I am striking out a new path for myself”
- 1729: smallest number expressible as the sum of two cubes in two different ways.
- Find them.

Social Motivation: T ↔ S

- Mutually interacting; rapport with students.
- Students trust you.
- Some students study because they like the teacher; they remember your "care" more than the "math".
- You are there for them, during lessons.
- Teachers' Vision (2009): We lead, care, inspire.
- Record positive things about your students.

Social Motivation: S ↔ S

- Sense of belonging, recognition; a goal of schooling.
- Encourage groups to like math; peer approval.
- Make students feel that they are learning together; community of learners.
- Introvert students; engage them differently. Cain (2012).

? Reduce unhealthy competition to outperform or impress others (ego-related).

Targets: Goals, Directions

- Dr Seuss: *You have brains in your head. You have feet in your shoes. You can steer* yourself *in any direction you choose.*
- Help students get targets, goals, directions in their math learning: meanings, skills, joy, etc.

Targets: Goals (Students)

- Motivated to achieve aspired targets/goals.
- Immediate targets: do what is expected, please parents, teachers, peers (extrinsic); token economy; avoid punishments.
- Short-term targets; mastery goal, performance goal; intrinsic (relevant, enjoy); extrinsic.
- Future goals; career aspirations.
- Help students clarify their targets; write down, monitor.

Monetary Targets

- US: Roland Fryer (2010)
- New York City, 15,800 4th and 7th graders, paid to improve test scores (English & Math)
- 7th graders: $10 to complete a test, $50 perfect score; 10 tests in a year. Average earning: $231. Total cost: $6 million
- Results?

Let Students Have Choices

- Choice and autonomy; not in Syllabus.
- Western theories. Students have choice in
  - what tasks to do,
  - how to do them,
  - when to do,
  - with whom (to work with)
  - judging quality of work.
- How much choice do you give?

M_Crest: Summary

- M_Meaningful;
- C_Confident;
- R_Relevant;
- E_Enjoyable;
- S_Social;
- T_Targets;

Activity: Homework

- How to motivate students to complete math homework?
- Write down some responses based on M_Crest and types of motivation.

Research

1. Students' level of engagement with specific tasks; SMAPP. Use data to design more appropriate tasks.
2. Students' motivational attributes (general vs. math); TIMSS 2011; Sandman. Use data to enhance rapport; advise students about effective learning.
3. Reflection about your practice.

Specific Tasks: SMAPP

- Rate each task on 4-point scale: Interesting; Relevant to daily life; Challenging; Confidence in my answers.
- Open-ended comments.
- Relevant, quite "obvious".

Questions	Interesting	Relevant	Challenging	Confidence
1 (Tourism)	2.40	2.21	2.95	2.18
2 (Earthquakes)	2.62	2.32	3.20	2.00
3 (Mobile Plans)	2.51	3.09	3.06	2.11
4 (Fire)	2.64	2.65	2.93	2.15
5 (Road Deaths)	2.46	2.51	3.21	1.86

TIMSS 2011: Confidence

1. I usually do well in mathematics.
2. Mathematics is harder for me than for many of my classmates.
3. I am just not good at mathematics. (reverse)
4. I learn things quickly in mathematics.
5. I am good at working out difficult mathematics problems.
6. My teacher tells me I am good at mathematics.
7. Mathematics is harder for me than any other subject. (reverse)

- 4-point scale: Agree a lot, agree a little, disagree a little, disagree a lot.

TIMSS 2011: Value Math (Relevance)

1. I think learning mathematics will help me in my daily life.
2. I need mathematics to learn other school subjects.
3. I need to do well in mathematics to get into the university of my choice.
4. I need to do well in mathematics to get the job I want.
5. I would like a job that involves using mathematics.
6. It is important to do well in mathematics.

TIMSS 2011: Like Learning Math (Enjoy)

1. I enjoy learning mathematics.
2. I wish I did not have to study mathematics. (reverse)
3. Mathematics is boring. (reverse)
4. I learn many interesting things in mathematics.
5. I like mathematics.

Other Constructs

- Write your own items about Meaningful, Social, Targets.

1. It is important that Mathematics makes sense to me.
2. I am more engaged when I work with my friends.
3. I prefer to work from simple to difficult problems.

Sandman: Motivation

- Sandman (1979): Motivation in Maths. 5-point scale.

*MI. I like the easy mathematics problems best.

M2. I would like to do some outside reading in mathematics.

M3. Sometimes I read ahead in our mathematics book.

M4. Sometimes I work more mathematics problems than are assigned in class.

*M5. I would rather be given the right answer to a mathematics problem than to work it out myself.

*M6. The only reason I'm taking mathematics is because I have to.

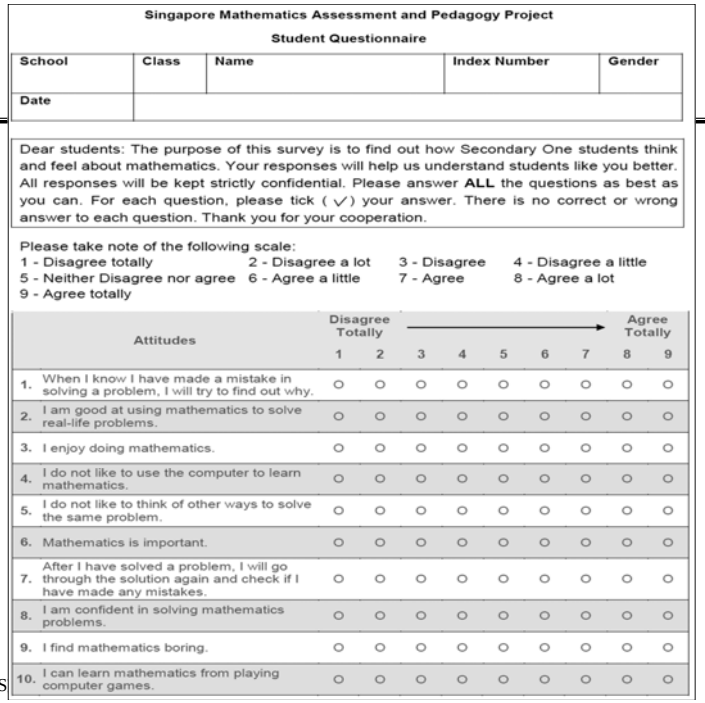
M7. It is important to me to understand the work I do in mathematics.

M9. I have a real desire to learn mathematics.

SMAPP: ALMQ Results

- 6 constructs, 4 items per construct. 9-point scale. Validated.
- S1 Express, 2011. (* statistically significant)

Scales	Girls	Boys
N	551	296
Check solutions	6.14	6.05
Confidence	4.77	5.14 *
Enjoyment	5.67	5.92
Use of IT	5.15	5.44 *
Multiple solutions	5.42	5.61
Usefulness (Relevance)	6.41	6.51



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

Attitudes	Disagree Totally 1	2	3	4	5	6	7	8	Agree Totally 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

Lim Siew Yee (2010)

- 984 JC students.
- Achievement test: similar to H2 paper.
- Correlations with achievement: (* $p < .01$) [mean, 5-point]
  - Intrinsic motivation: 0.36 * [2.82]
  - Extrinsic motivation: -0.05 [3.03]
  - General motivation: 0.47 * [3.04]
  - Enjoyment: 0.48 * [3.30]
  - Self-confidence: 0.60 * [3.34]
  - Value of math: 0.31 * [3.49]

Reflection: Your Practice

- For the past week:

1. What feedback did you seek from students about their motivation?
2. What had you done to motivate (whole class, individual students) using the (rewards, …) motivators?
3. How might this reflection change your plan for the following week to engage the reluctant or disengaged students?

- Share reflections with colleagues; PLC.

Final Remarks