

AME – SMS CONFERENCE 2015

Keynote VI (Primary)

21st Century Competencies & Singapore Mathematics Curriculum

Based the 21st Century Competencies Framework and the Singapore Mathematics Curriculum Framework established by the Singapore Ministry of Education, an effort to establish the link between the two will be presented at this talk. This would provide a basis for teachers to see the relevance of 21st Century Competencies in the Singapore Mathematics classroom. The talk will then present some instructional approaches that teachers could employ to support the development of 21st Century Competencies in the context of the Primary Mathematics classrooms.

Lee Ngan Hoe

nganhoe.lee@nie.edu.sg

Mathematics & Mathematics Education / National Institute of Education

OVERVIEW

- 21st Century Skills
- Singapore Mathematics Curriculum
- Singapore Mathematics Classrooms
- Conclusion – A Reflection

21 CC

The 21st century is the current century of the Anno Domini era or the Common Era, in accordance with the Gregorian calendar. It began on January 1, 2001, and will end on December 31, 2100. It is the first century of the 3rd millennium.

Jacobs (2010, Introduction, para 4) noted that “[T]here is a rising concern about 21st century skills and tools for our learners, although it is noteworthy that as of the writing of this book, almost 10 percent of the 21st Century has already passed”.

Ref:

Note: It is distinct from the century known as the 2000s, which began on January 1, 2000 and will end December 31, 2099.

Source: wikipedia - http://en.wikipedia.org/wiki/21st_century. Retrieved on 1 June 2015.

21 CC

I often wonder if many of our students feel like they are *time traveling* as they walk through the school door each morning. As they cross the threshold, do they feel as if they are entering a simulation of life in the 1980s? Then, at the end of the school day, do they feel that they have returned to the 21st century? As educators, our challenge is to match the needs of our learners to a *world that is changing with great rapidity*. To meet this challenge, we need to become strategic learners ourselves by deliberately expanding our perspectives and updating our approaches.

Jacobs (2010, Chapter 1, para 1)

21 CC

MOE 21CC FRAMEWORK (2014 onwards)

Why 21st century competencies?

Globalisation, changing demographics and technological advancements are some of the key driving forces of the future. Our students will have to be prepared to face these challenges and seize the opportunities brought about by these forces.

To help our students thrive in *a fast-changing world*, MOE has identified competencies that have become increasingly important in the globalised world of the 21st century. These enable students to tap into rich opportunities in the emerging digital age. It is envisaged that schools and parents need to work hand-in-hand to help our students develop these 21st century competencies. A strong partnership between the home and the school will put our children in good stead for the future.

Source: MOE, OPAL -

<http://21cc.opal.moe.edu.sg/cos/o.x?c=/21cc/pagetree&func=view&rid=1929>

21 CC

**The 21st Century is century
that is marked by rapid changes.**

21 CC

MOE 21CC FRAMEWORK (2014 onwards)

The Framework

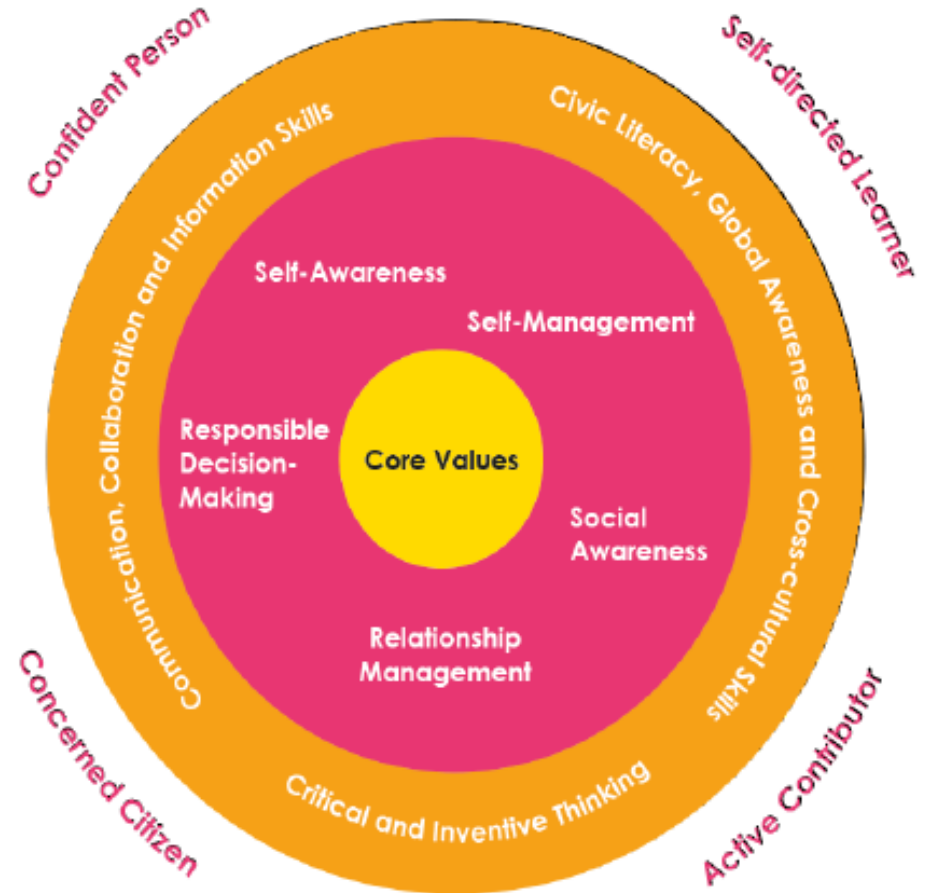
Knowledge and skills must be underpinned by values. Values define a person's character. They shape the beliefs, attitudes and actions of a person, and therefore form the core of the framework of 21st century competencies.

The middle ring signifies the Social and Emotional competencies – skills necessary for children to recognise and manage their emotions, develop care and concern for others, make responsible decisions, establish positive relationships, as well as to handle challenging situations effectively.

The outer ring of the framework represents the emerging 21st century competencies necessary for the globalised world we live in. These are:

- Civic Literacy, Global Awareness and Cross-Cultural Skills
- Critical and Inventive Thinking
- Communication, Collaboration and Information Skills

Together, these competencies will enable our young to tap into the rich opportunities in the new digital age, while keeping a strong Singapore heartbeat.



Source: MOE, OPAL -

<http://21cc.opal.moe.edu.sg/cos/o.x?c=/21cc/pagetree&func=view&rid=1929>

21 CC

Competencies for the 21st century

Civic Literacy, Global Awareness and Cross-cultural Skills

Our society is becoming increasingly cosmopolitan and more Singaporeans live and work abroad. Our young will therefore need a broader worldview, and the ability to work with people from diverse cultural backgrounds, with different ideas and perspectives. At the same time, they should be informed about national issues, take pride in being Singaporean and contribute actively to the community.

Critical and Inventive Thinking

To be future-ready, our young need to be able to think critically, assess options and make sound decisions. They should have a desire to learn, explore and be prepared to think out of the box. They should not be afraid to make mistakes and face challenges that may at first appear daunting.

Communication, Collaboration and Information Skills

With the Internet Revolution, information is often literally just a click away. It is important that our young know what questions to ask, how to sieve information and extract that which is relevant and useful. At the same time, they need to be discerning so that they can shield themselves from harm, while adopting ethical practices in cyberspace. Importantly, they should be able to communicate their ideas clearly and collaborate effectively with others.

Source: MOE, OPAL -

<http://21cc.opal.moe.edu.sg/cos/o.x?c=/21cc/pagetree&func=view&rid=1929>

21 CC

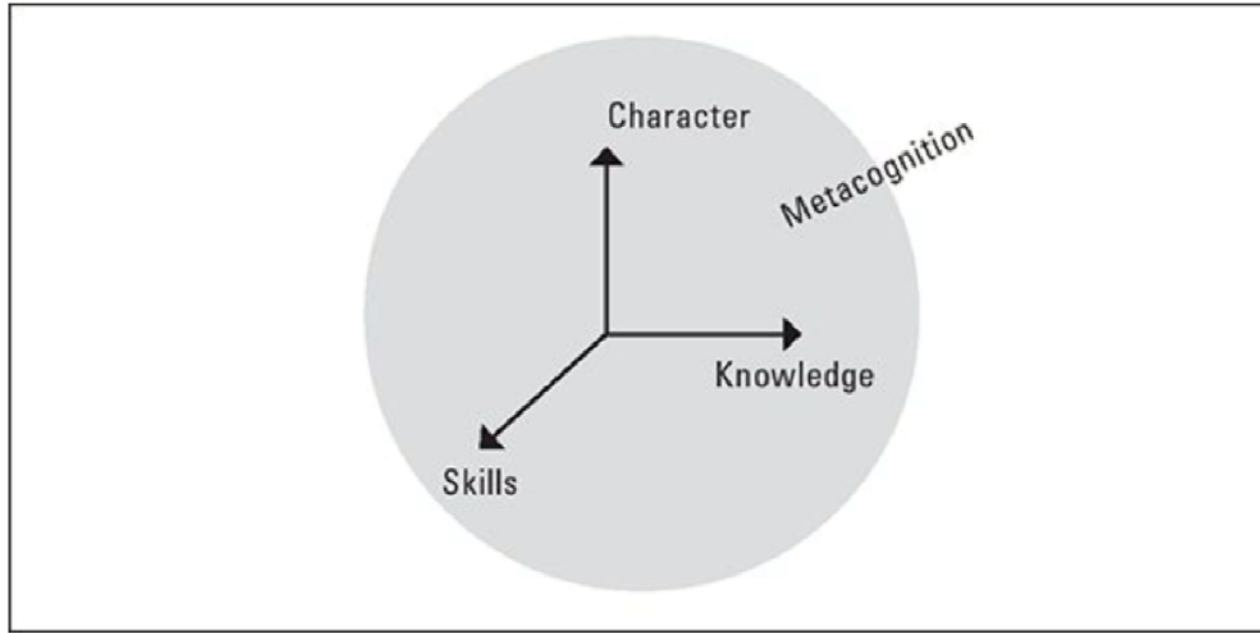
Emerging 21st Century Competency Domains and Components

- **Civic Literacy, Global Awareness and Cross-Cultural Skills**
 - Active Community Life
 - National and Cultural Identity
 - Global Awareness
 - Socio-Cultural and Religious Sensitivity and Awareness
- **Critical and Inventive Thinking**
 - Curiosity and Creativity
 - Sound Reasoning and Decision-Making
 - Metacognition
 - Managing Complexities and Ambiguities
- **Communication, Collaboration and Information Skills**
 - Effective Communication
 - Effective Collaboration
 - Management of Information
 - Responsible Participation in the Information Landscape

Source: MOE, OPAL -

http://mydesk.opal.moe.edu.sg/cos/o.x?c=/ca4_mydesk/grpcoll&func=getWallRes&wrid=9541

21 CC



Fadel (2015, Chapter 8, The Four Dimensions of an Education, para 1) observed that “the way in which adapting to 21st century needs means revisiting each of the four dimensions and their interplay”.

21 CC

Economists Frank Levy and Richard Murnane (2004, pp.53-54) highlighted an important component of what constitutes 21st century knowledge and skills:

“Declining portions of the labor force are engaged in jobs that consist primarily of routine cognitive work and routine manual labor – the types of tasks that are easiest to program computers to do. [Growing proportions of the nation’s labor force are engaged in jobs that emphasize expert thinking or complex communication – tasks that computers cannot do”

Components of expert thinking (p.75):

- (1) ‘effective pattern matching based on detailed knowledge’
- (2) “metacognition, the set of skills used by the stumped expert to decide when to give up on one strategy and what to try next”

“Complex communication requires the exchange of vast amounts of verbal and nonverbal information. The information flow is constantly adjusted as the communication evolves unpredictably” (p.94).

21 CC

Dede (2010, Chapter 3, Comparing Alternative Frameworks for 21st Century Skills, para 1) observed that “21st century skills frameworks are generally consistent with each other”. In particular, Dede highlighted the following sets of skills:

- Inventing new problem-solving heuristics when standard protocols have failed.
- Undertaking complex communication by improvising answers and facilitate dialogue in the unpredictable, chaotic flow of discussion.
- Working collaboratively, including accomplishing tasks through mediated interactions with peers halfway across the world whom one may never meet face-to-face.
- Involving in “disorderly” knowledge co-creation and sharing, which includes access to, manage, integrate, and evaluate enormous amounts of data made available by the prevalence of ICTs
- Applying expert decision-making and metacognitive strategies that indicate how to proceed when no standard approach seems applicable

21 CC

MOE's Emerging 21st Century Competency Domains and Components

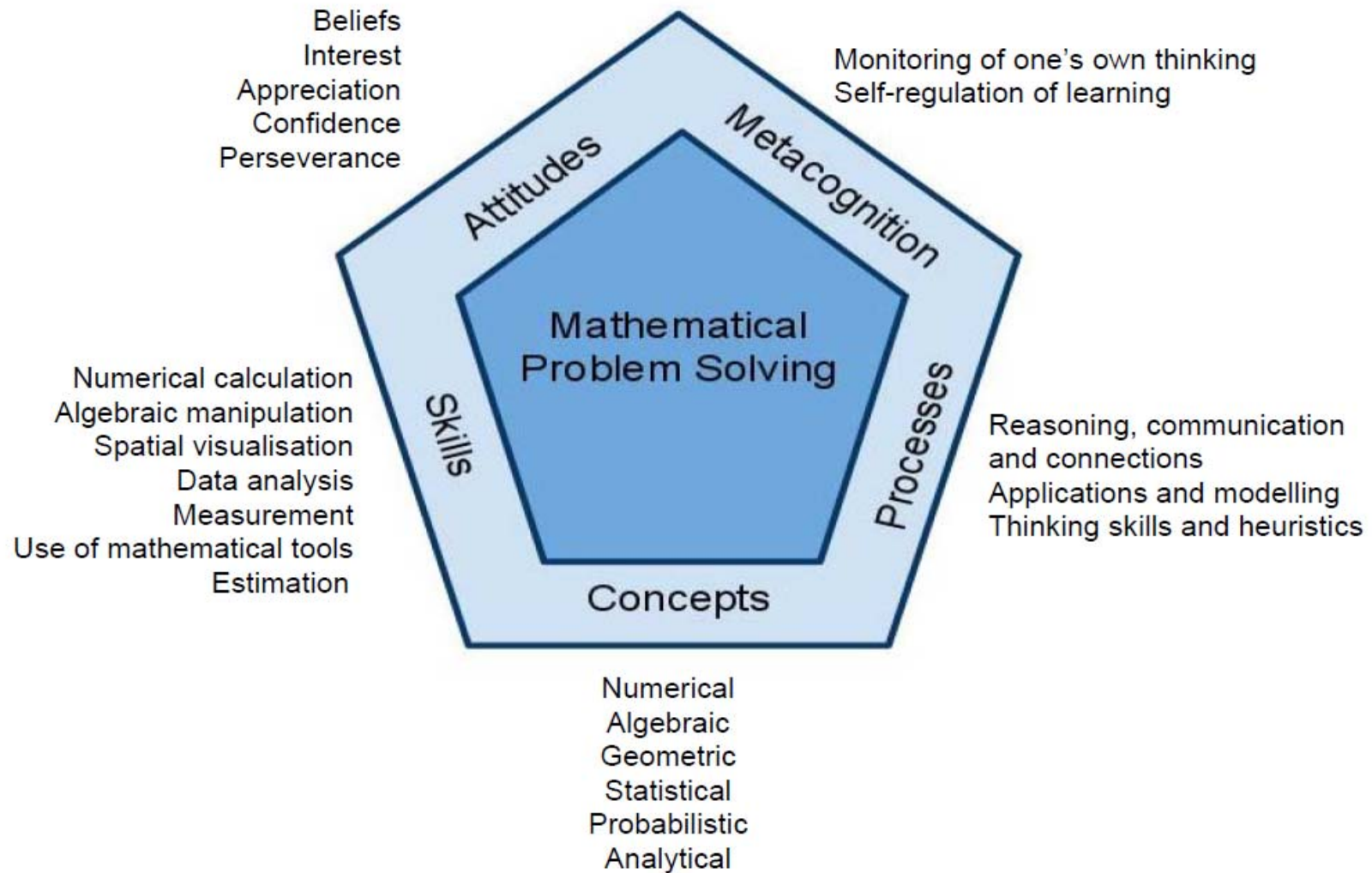
- **Civic Literacy, Global Awareness and Cross-Cultural Skills**
 - Active Community Life
 - National and Cultural Identity
 - Global Awareness
 - Socio-Cultural and Religious Sensitivity and Awareness
- **Critical and Inventive Thinking**
 - Curiosity and Creativity
 - Sound Reasoning and Decision-Making
 - Metacognition
 - Managing Complexities and Ambiguities
- **Communication, Collaboration and Information Skills**
 - Effective Communication
 - Effective Collaboration
 - Management of Information
 - Responsible Participation in the Information Landscape

Dede's (2015) comparison of Framework for 21st Century Skills

- Inventing new problem-solving heuristics when standard protocols have failed.
- Undertaking complex communication by improvising answers and facilitate dialogue in the unpredictable, chaotic flow of discussion.
- Working collaboratively, including accomplishing tasks through mediated interactions with peers halfway across the world whom one may never meet face-to-face.
- Involving in “discorderly” knowledge co-creation and sharing, which includes access to, manage, integrate, and evaluate enormous amounts of data made available by the prevalence of ICTs
- Applying expert decision-making and metacognitive strategies that indicate how to proceed when no standard approach seems applicable

Singapore Mathematics Curriculum

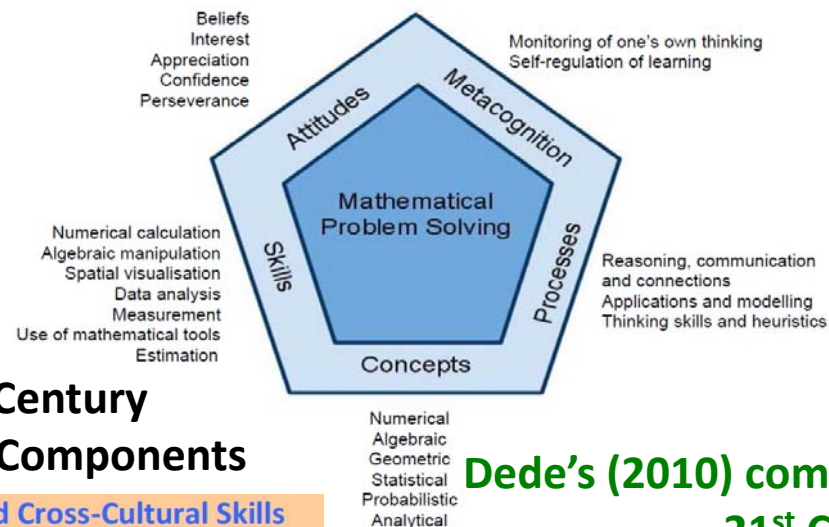
SINGAPORE MATHEMATICS CURRICULUM FRAMEWORK



Source: Ministry of Education. (2012). *Primary Mathematics Teaching and Learning Syllabus*. Singapore: Ministry of Education.

Singapore Mathematics Curriculum

SINGAPORE MATHEMATICS CURRICULUM FRAMEWORK



MOE's Emerging 21st Century Competency Domains and Components

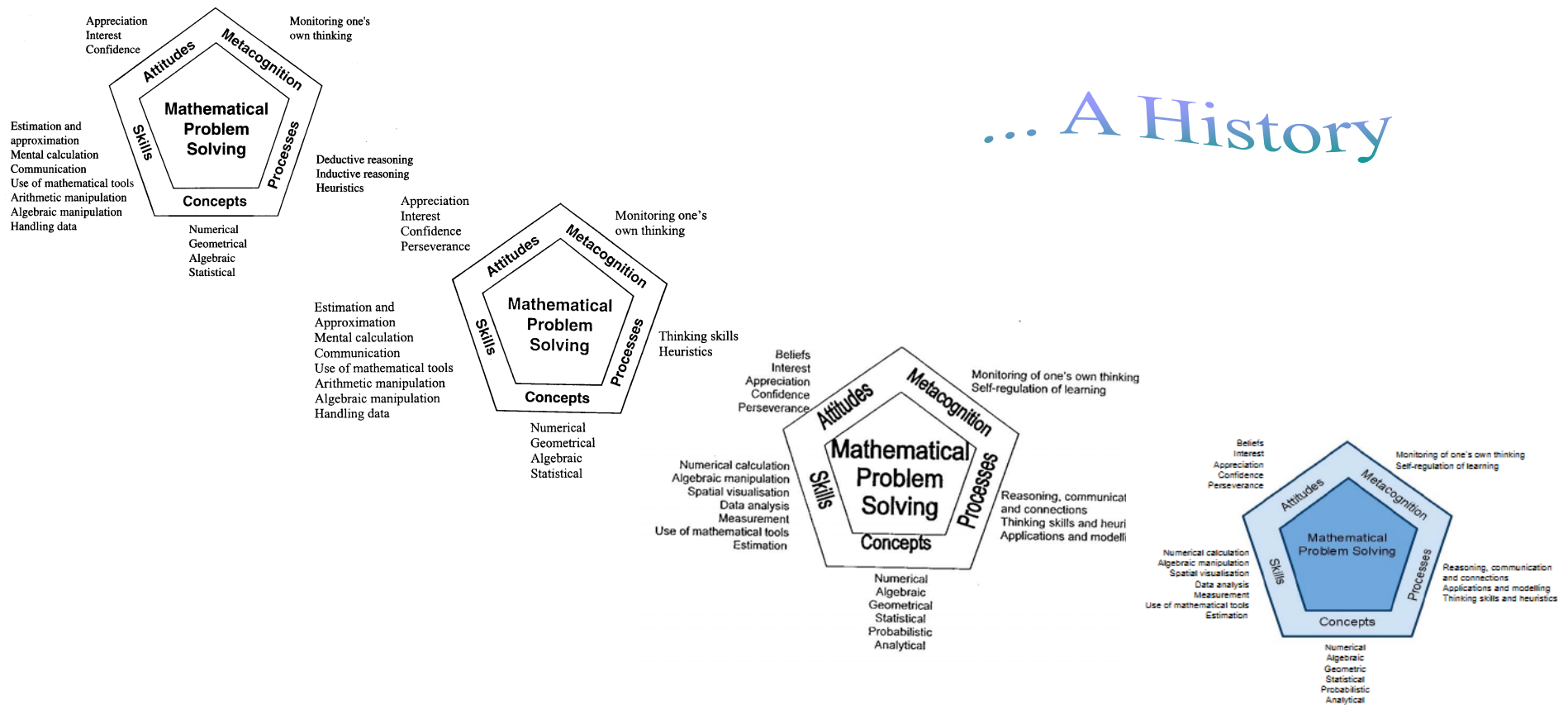
- **Civic Literacy, Global Awareness and Cross-Cultural Skills**
 - Active Community Life
 - National and Cultural Identity
 - Global Awareness
 - Socio-Cultural and Religious Sensitivity and Awareness
- **Critical and Inventive Thinking**
 - Curiosity and Creativity
 - Sound Reasoning and Decision-Making
 - Metacognition
 - Managing Complexities and Ambiguities
- **Communication, Collaboration and Information Skills**
 - Effective Communication
 - Effective Collaboration
 - Management of Information
 - Responsible Participation in the Information Landscape

Dede's (2010) comparison of Framework for 21st Century Skills

- Inventing new problem-solving heuristics when standard protocols have failed.
- Undertaking complex communication by improvising answers and facilitate dialogue in the unpredictable, chaotic flow of discussion.
- Working collaboratively, including accomplishing tasks through mediated interactions with peers halfway across the world whom one may never meet face-to-face.
- Involving in "discorderly" knowledge co-creation and sharing, which includes access to, manage, integrate, and evaluate enormous amounts of data made available by the prevalence of ICTs
- Applying expert decision-making and metacognitive strategies that indicate how to proceed when no standard approach seems applicable

Singapore Mathematics Curriculum

SINGAPORE MATHEMATICS CURRICULUM FRAMEWORK



1992



2001



2007



2013

Singapore Mathematics Curriculum

The Framework for the Singapore Mathematics Curriculum, developed in 1990, for example, survived, with minor modification, the major curriculum review for the 2000 syllabuses which took into account the three new Initiatives. One of the key reasons for the Framework's survival is its rigour and robustness in presenting the philosophy and principles underlying decisions made about what mathematics education should equip our students with.

Lee, N.H. (2008). Nation Building Initiative: Impact on Singapore Mathematics Curriculum. In Niss, M. (Ed.) *10th International Congress on Mathematical Education Proceedings (CD)*. Copenhagen: Roskilde University.

Singapore Mathematics Curriculum

Dede (2010, Chapter 3, Comparing Alternative Frameworks for 21st Century Skills, para 1 to 2) observed that though “21st century skills frameworks are generally consistent with each other” ... “groups ... stress some areas they feel are underemphasized”.

Singapore Mathematics Classrooms

Syllabus Organisation

The syllabus is organised along 3 content strands with a listing of mathematical processes that cut across the 3 strands.

3 Content Strands + 1 Process Strand		
Number and Algebra	Measurement and Geometry	Statistics
Mathematical Processes		

Source: Ministry of Education. (2012). *Primary Mathematics Teaching and Learning Syllabus*. Singapore: Ministry of Education.

Singapore Mathematics Classrooms

Learning Experiences

It matters how students learn

Learning mathematics is more than just learning concepts and skills. Equally important are the cognitive and metacognitive process skills. These processes are learned through carefully constructed learning experiences. For example, to encourage students to be inquisitive, the learning experiences must include opportunities where students discover mathematical results on their own. To support the development of collaborative and communication skills, students must be given opportunities to work together on a problem and present their ideas using appropriate mathematical language and methods. To develop habits of self-directed learning, students must be given opportunities to set learning goals and work towards them purposefully. A classroom, rich with these opportunities, will provide the platform for students to develop these 21st century competencies.

Source: Ministry of Education. (2012). *Primary Mathematics Teaching and Learning Syllabus*. Singapore: Ministry of Education.

Singapore Mathematics Classrooms

Two issues of concern ...

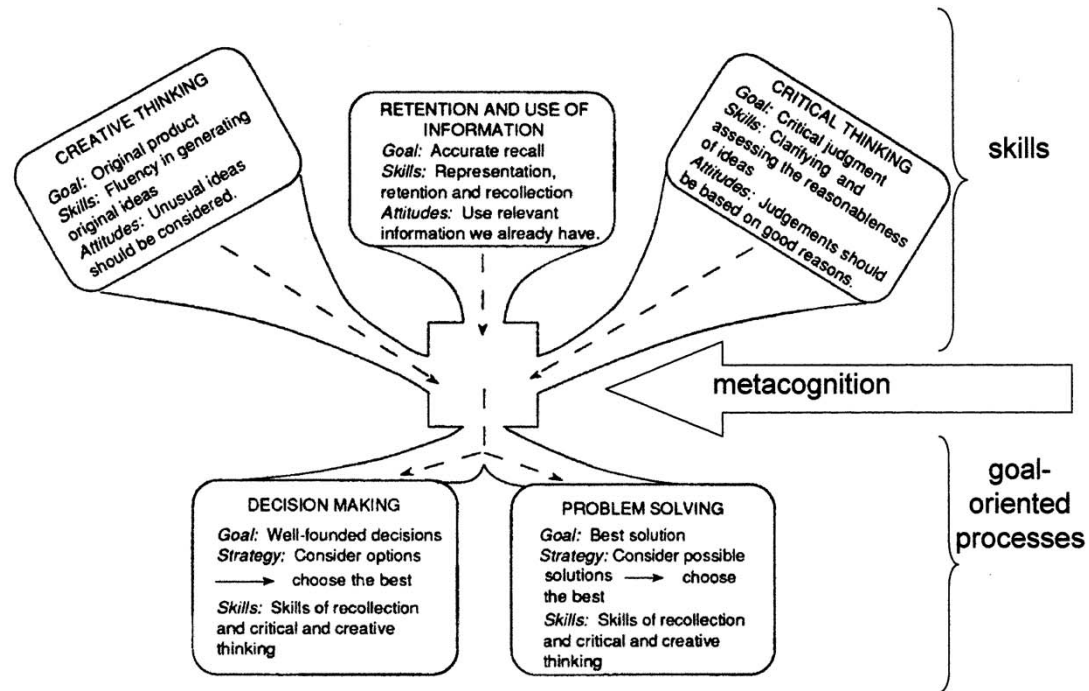
Thinking skills and heuristics are essential for mathematical problem solving. Thinking skills are skills that can be used in a thinking process, such as classifying, comparing, analysing parts and whole, identifying patterns and relationships, induction, deduction, generalising, and spatial visualisation. Heuristics are general rules of thumb of what students can do to tackle a problem when the solution to the problem is not obvious. These include using a representation (e.g., drawing a diagram, tabulating), making a guess (e.g., trial and error/guess and check, making a supposition), walking through the process (e.g., acting it out, working backwards) and changing the problem (e.g., simplifying the problem, considering special cases).

Metacognition, or thinking about thinking, refers to the awareness of, and the ability to control one's thinking processes, in particular the selection and use of problem-solving strategies. It includes monitoring of one's own thinking, and self-regulation of learning.

To develop metacognitive awareness and strategies, and know when and how to use the strategies, students should have opportunities to solve non-routine and open-ended problems, to discuss their solutions, to think aloud and reflect on what they are doing, and to keep track of how things are going and make changes when necessary.

Singapore Mathematics Classrooms

What constitutes thinking?



Map of the Thinking Domain (Swartz & Perkins, 1990)

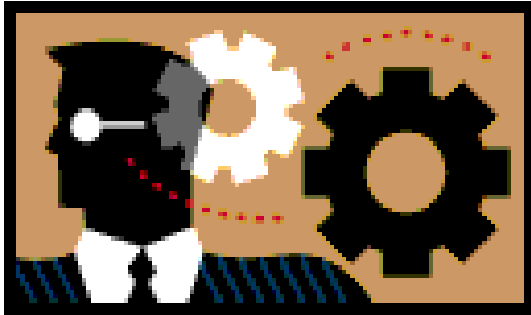
Singapore Mathematics Classrooms

Two Suggestions:

1. Make teaching of thinking skills explicit – both the vocabulary as well as the steps involved in the cognitive activity. This would promote communication as well as teaching for transfer (deeper learning (Pellegrino, 2015, The What: Issues of Construct Definition, Para 2)).
1. Provide opportunities in regular lessons for students to develop metacognition as productive habit of mind; this can take in the form of both online or offline metacognition. It helps to create a greater awareness of one's cognitive resources for strategic use during problem solving.

Singapore Mathematics Classrooms

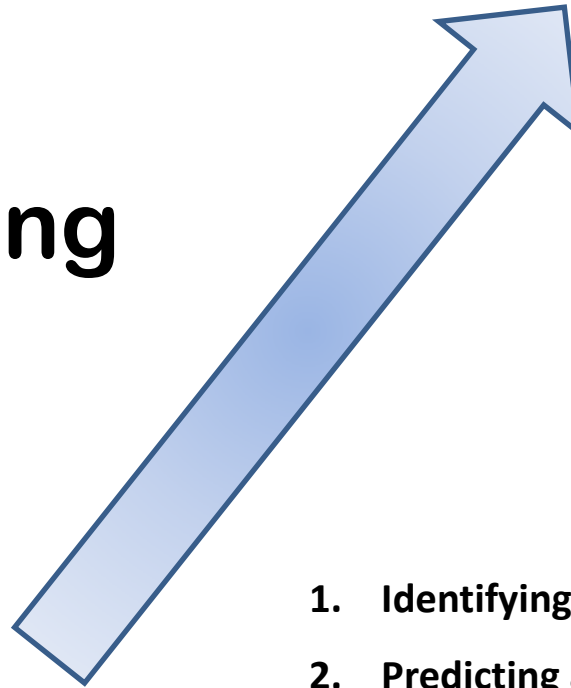
Example 1 – Teaching Equivalent Fractions



Inductive Thinking

Specific

General



1. Identifying patterns & relationships
2. Predicting a rule
3. Verifying a rule

Singapore Mathematics Classrooms

Example 2 – Lesson Conclusion

Suggested sequence of teaching actions to promote reflective (offline metacognitive) learning:

- Get pupils to close their eyes for half to a minute to recall what was learnt.
- Get pupils to share what they have learnt.
- Teacher to capture pupils' responses on board.
- Teacher to fill in the gaps that pupils' might have left out.
- Assign homework aligned with lesson objectives.
- If there's time left, pupils may commence on homework

Conclusion – A Reflection

Dede (2010, Chapter 3, Comparing Alternative Frameworks for 21st Century Skills, para 3):

“The stress on skills that may be underemphasized because they are inconsistent with current classroom culture highlights a substantial challenge to infusing these 21st century skills frameworks into educational practice and policy. At this point in history, the primary barriers to altering curricular, pedagogical, and assessment practices are not conceptual, technical, or economic, but instead psychological, political, and cultural. We now have all the means necessary to move beyond teaching 20th century knowledge in order to prepare all students for a future quite different from the immediate past. Whether society has the professional commitment and public will to actualize such a vision remains to be seen”.

Conclusion – A Reflection

Despite differences in sociocultural contexts, 21st century skills frameworks, including that developed by MOE, are generally consistent with each other. The Singapore Mathematics Curriculum has thus far been sufficiently rigorous and robust to reflect not only the needs of the discipline but also the related skills needed to prepare our pupils for the 21st century life and workplace. However, there is a need to identify areas that are underemphasized and more efforts should be made to address these. Not only the content but also the process skills need to be supported by explicit instruction whereby these are explicitly labelled and discussed and pupils are guided throughout their repeated distributed practice of these. This is in line with previous findings that critical thinking skills can be learned and transferred to novel situations when pupils receive explicit instruction designed to foster transfer (Bangert-Drowns & Bankert, 1990; Cotton, 1991; Dweck, 2002, Halpern, 1998, 2003; Marin & Halpern 2011)

QUESTIONS & DISCUSSION

Thank you.

Lee Ngan Hoe

nganhoe.lee@nie.edu.sg

Mathematics & Mathematics Education / National Institute of Education