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► **To cite this version:**

Qiaoping Zhang, Chung Yin Lam. Mathematics teachers' mathematics educational values in teaching: A case study in Hong Kong. Thirteenth Congress of the European Society for Research in Mathematics Education (CERME13), Alfréd Rényi Institute of Mathematics; Eötvös Loránd University of Budapest, Jul 2023, Budapest, Hungary. hal-04420681

HAL Id: hal-04420681

<https://hal.science/hal-04420681>

Submitted on 26 Jan 2024

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Mathematics teachers' mathematics educational values in teaching: A case study in Hong Kong

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Present study explored what kinds of and how mathematics educational values are espoused in mathematics classroom by classroom observation and interviewing two in-service mathematics teachers in primary and secondary schools in Hong Kong. The preliminary results revealed a significant difference in teachers' values. Primary mathematics teaching (PMT) emphasised fun, flexibility, critical thinking, and coherence, while secondary mathematics teaching (SMT) focused on achievement, control, high order thinking, and progression. Using existing theoretical framework, the primary teacher was prone to an activist view, relational, relevance, and accessibility, in contrast to the secondary teacher, though students' motivation and exploration were co-valued by them. We argued that the contrast was due to teachers' value shift in response to students' educational stage and social expectations, reflecting the challenges of STEM talent cultivation in Hong Kong.

Keywords: Values in mathematics education, mathematics educational values, mathematics teachers.

Background and Literature Review

Values have traditionally played a vital role in school education. Bishop (1996) introduced the notion that “values in mathematics education are the deep affective qualities which education aims to foster through the school subject of mathematics” (p. 19). It shapes the individual's willpower to embody the convictions in the choice of actions, contributing to the individual's thrive ability in ethical mathematics pedagogy (Seah, 2019, p. 107). Teachers' values would influence their teaching, from class planning to interactions with students, ways of posing questions, and assessment (Lin et al., 2006; Dede, 2015). Literatures have considerable discussions on the teachers' mathematics educational values (Seah & Bishop, 2000), and suggest variation in mathematics educational values across different cultures, countries, school types and grades (Dede, 2006). Different mathematics teachers would emphasize different aspects of mathematics teaching and learning, despite the shared societal values in the same context (Dede, 2015). Most studies on teachers' values were conducted in the Western educational system, such as Australia (Bishop et al., 2005), Israel (Daher, 2019), Norway and South Africa (Kacerja & Julie, 2023), and Turkey (Dede, 2011, 2015), seldom delved into Asian culture particularly Chinese context. Present study aimed at filling the void by investigating the similarities and differences of mathematics educational values between primary and secondary school mathematics teachers in Hong Kong.

Mathematics educational values refer to the values related to norms and practices emerged from the mathematics education (Seah & Bishop, 2000), which could be categorised into five complementary pairs, namely formalistic view-activist view, instrumental-relational understanding/learning, relevance-theoretical knowledge, accessibility-special, and evaluating-reasoning (Seah & Bishop, 2000). Dede (2006) considered the former two as pedagogical side of mathematics education while the rest as cultural. Seah et al. (2001) and Dede (2011) summarized several mathematics educational

values that were commonly observed, including accuracy, clarity, efficiency, systematic working, effective organization, flexibility, open-mindedness, conjecturing, creativity, enjoyment, and persistence.

Mathematics educational values are culture sensitive. In Dede (2015)'s study, he suggested that countries like Turkey (Germany) as a collective (individualistic) society tended to be teacher-centred (student-centred), having a large (small) power distance and large (small) uncertainty avoidance. In actual implementation, teachers could convey their mathematics educational values implicitly in class. For example, rather than saying explicitly "For exam purpose", when a teacher instructs, "Make sure you show all the working in your answers", the value "examination-wisdom" is conveyed (Dede, 2015). However, teachers' values demonstrated in classroom depends on several factors, including teachers' awareness, willingness to actualize the values, and classroom environment (Lin et al., 2006). Studies have showed that primary and secondary mathematics teachers hold different beliefs (Perry et al., 2006) and values (Bishop et al., 2005). For instance, primary mathematics teachers preferred empiricism to rationalism (Bishop et al., 2005) and process to product pedagogically (FitzSimons et al., 2001), while secondary teachers emphasised rationalism (Bishop et al., 2005). Present study aimed at examining the similarities and differences in mathematics educational values between primary and secondary in-service mathematics teachers in Hong Kong.

Methods

As an exploratory qualitative study, two Hong Kong in-service mathematics panel teachers were invited— one female teacher from primary school and another male teacher from secondary school, with an aim to reveal gender differences in perspectives, if any. Both were serving local aided schools and delivered the mathematics curriculum recommended by the Hong Kong Education Bureau (Curriculum Development Council, 2002). The fieldwork took place from May to June 2018. Grade 5 and Grade 9 were selected as both were at the end of the learning cycle of primary and junior secondary education respectively. Additionally, both interviewed teachers planned to teach algebra, providing a common ground for discussion. In the two classrooms respectively, we first conducted a "40-minute classroom observation" twice, followed by about 45-minute in-depth interview with the teacher. The key interview questions are summarized as below in Table 1. We referenced the video recording of classroom observations, audio recording under the consent of the two teachers and the transcripts for data analysis. To ensure research reliability, two researchers prepared the coding and identified themes separately and then discussed to reach mutual agreement.

Table 1: Design of interview questions

Research questions	Describing questions
RQ1: What are the similarities and differences in mathematics educational values of Hong Kong primary and secondary mathematics teachers?	<ol style="list-style-type: none"> 1. What is the most important thing to your students in mathematics learning? 2. What do you value most in your mathematics teaching?

RQ2: How do mathematics teachers in Hong Kong carry out their values in their teaching?	<ol style="list-style-type: none"> 1. How do you carry it out? 2. How do you overcome the challenges?
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Findings

In the Grade 5 mathematics classroom, the two lessons observed were teaching algebra and solving equation with one unknown. Ms. Chan wrote a few questions on the whiteboard and invited students to share their answers on the board. In the interview, she highlighted the importance of fun learning, critical thinking, exploration, flexibility (using different methods to reach the answers) and life-relevant examples in primary education.

Interviewer: What do you mean by “fun learning”?

Ms. Chan: Fun learning is the most important. If they like maths, they will take initiation to learn and enjoy it ... The seeds of interest planted today will sprout tomorrow.

Interviewer: How do you carry out “fun learning” in class?

Ms. Chan: Draw their attention, this is the first step to make them listen and understand the content. Sometimes I will ask, “can you think of other ways to speed up our calculation?” They have to think, critically, and explore their own ways. For example, I don’t see the need to have two formulae for perimeter of square and rectangle, the ideas behind is just the same, so I’ll just give them some clues to find out why. Sometimes I find myself like a shepherd, directing them to the sheep pen, but there’s no designated path, the sheep can go freely as long as they head to the same direction... Instead of cramming, this can deepen their memory.

Interviewer: How do you draw their attention?

Ms. Chan: I usually use some daily life examples so that they can understand better and find the content more interesting and relevant... For example, if the algebraic question is about “splitting the flowers”, they can’t get it. But if you ask them to “distribute a bag of candy to a few kids”, they will know right away what you mean.

Interviewer: So you point out “relevant”, life-related...

Ms. Chan: Relevant to them, to their life, making sense to them... Even in the solving equation exercises, I ask them to write the conclusion clearly, making sense to our life. Maths helps express your ideas in a logical manner.

Ms. Chan also stressed the values of coherence (connecting different stages of learning across the curriculum) and confidence in primary mathematics education.

Interviewer: You did a quick review on multiplication in class, why?

Ms. Chan: It represents the basics of factorization. Before starting to solve equations, I notice that some of them are not familiar with simple factorization concepts. They don’t know that “ 240×120 ” can be presented in “ $240 \times 100 + 240 \times 20$ ”. This concept is essential in secondary math learning... Sometimes the textbooks simply skip all the fundamentals and assume all students have learnt it before. In fact, teachers need to help them review what they have learnt before discussing the topic in depth.

Interviewer: The students look at ease when they present their workings on the whiteboard.

Ms. Chan: Not at the beginning. It’s important to make them feel secure when airing opinions. I welcome all kinds of thoughts if they are relevant to our learning... This is essential for building their self-confidence, and confidence in maths learning.

In the Grade 9 mathematics classroom, the two lessons observed were teaching algebraic equation and properties of 3D shapes. Mr. Lam introduced the topics and skills in due order. In the interview, he explained why it mattered much to students’ sense of achievement, confidence, and perseverance. He also shared his values on control, practice, and progressive learning.

Interviewer: What is the most important thing in students' maths learning? How do you help them realize it?

Mr. Lam: Achievement is very important to students. Frankly speaking, my students are not the tip top. Starting with the basics makes it easier for them to understand and give them a taste of achievement. A tick on a question symbolises an intrinsic reward, fuelling their confidence, motivation to learn and persistence in overcoming the more complicated questions. Usually, I'll start with the simplest concepts and workings, so they can have some basic training on the easiest questions.

Interviewer: How do you design their practice and exercises?

Mr. Lam: I don't suggest lots of homework or rote learning, but for each topic, practice is still a must, so that students can master the skills across different question types.

Interviewer: Examination skills, right?

Mr. Lam: Yes, after calculation, the next step is the application questions. It is not enough to just solve an equation or a congruent triangle, they have to know how to present their conclusion statement... After meeting the syllabus requirement, I'll embed some content to pave their way for M1 (Calculus and Statistics) and M2 (Algebra and Calculus) studies in the next few years.

Mr. Lam accentuated the values of high order thinking, exploration, and relevance.

Interviewer: A step-by-step approach that connects them to the senior education. Given that some may choose Art stream after Form 3, can all of them be able to catch up with the advanced learning content?

Mr. Lam: For each chapter, there are some so-called "challenging questions" connecting them to the advanced level, but I won't expect all of them to be able to master these questions. Usually when we touch on these questions, students have already learnt all the concepts and skills required. I just want them to think more, from different angles, figuring out different ways or alternative answers to the problems. If I don't stretch their boundary and push them up to a higher level, they won't have chance to hone their high order thinking skills, they won't think about how the cylinder surface changes with different cuts.

Interviewer: In your lesson teaching properties of 3D shapes, you have used pencil case and water bottle for demonstration. Why?

Mr. Lam: Some students can imagine the shapes, but some cannot. Using objects that can be easily found in daily life helps visualise the shapes and ease their imagination. For example, properties of quadrilateral – students can just observe their pencil boxes and grasp the idea of parallel lines. Another example is algebraic questions. Students may find the algebra "x" and "y" difficult to manage, but if you use "pigs" and "ducks" in a farm scene, the problem makes more sense to them.

Discussion

In our primary school case study, the mathematics educational values identified were fun, flexibility, relevance, critical thinking, coherence, exploration, and confidence; while in the secondary school case study, the values identified were practice, achievement, framework, relevance, high order thinking, perseverance, progressive, exploration, and confidence.

In our primary school case, fun was the most critical value, as it helped capture and extend the attention span of the young kids, actively engage the young learners in class, and foster their learning interest in mathematics. However, in our secondary school case, achievement was the most critical value. Hong Kong has long been commented as exam-driven where parents hold a high expectation of students' public examination results (Tan, 2019). Against this backdrop, local SMT is tasked to equip students with solid exam skills. The divergence in mathematics educational values observed in our two cases gave rise to the pedagogical differences. In PMT, given less intense syllabus schedule

and simpler concepts involved, there was leeway to provide students with flexibility and exploration. However, in SMT, teacher-led guidelines appeared to be a framework directing students to think and discuss, implying the value of control. To equip students the examination skills, working on different question types, getting familiar with the logic behind and detailing the working were inevitable. All these pointed to the value of practice. Though exploration was a common value shared in our case study, when the discipline gradually became more specialised, exploring different solutions and challenging the advanced questions seemed to be a “privilege” of bright students.

The intellectual virtues emphasised in the two schools interviewed were quite different. PMT focused on students’ critical thinking and confidence, where a learning environment that welcomed trial-and-error was crucial to bring young students a sense of security and gradually establish their confidence in mathematics learning. Confidence building was a common value observed in both schools. However, SMT emphasised more the high order thinking and perseverance. High order thinking skills came to play bridging students to the public examination curriculum gradually. Meanwhile, the challenging mathematics problems was expected to train students’ perseverance in problem solving.

For instructional content arrangement, both teachers in our case study valued relevance to life to ease students’ understanding and enable them to see the significance of their learning. Nevertheless, the primary teacher highlighted more learning coherence whilst the secondary teacher stressed progression. Coherence refers to the vertical integration of the mathematics curriculum, where teachers help link different stages of learning based on the sequential organization of the curriculum (Hassan, 2013), promoting the knowledge integration of students. In Hong Kong, factorization is a mathematics concept spanning over primary and secondary curriculum. Adopting vertical integration of mathematics in primary education could help students recall their memory and connect their knowns to the unknowns. Whereas, progression mattered more in secondary learning, questions were posed from primary to advance level to cater to students’ learning differences and ease their mastery. Table 2 below summarized the similarities and differences in teachers’ mathematics educational values in primary and secondary schools in Hong Kong.

Table 2: Similarities and differences in teachers’ mathematics educational values

	Primary	Secondary	Difference
1. Most important values based on students’ educational stage	Fun	Achievement	✓
2. Related to Pedagogy	Flexibility	Control	✓
	-	Practice	✓
	Exploration	Exploration	-
3. Related to students’ intellectual virtues	Critical thinking	High order thinking	✓
	Confidence	Confidence	-

	-	Perseverance	✓
4. Related to the instructional content arrangement	Relevance	Relevance	-
	Coherence	Progression	✓

Using Seah & Bishop (2000)'s five complementary pairs of mathematics educational values as our analysis framework, our study showed that PMT adopted an activist view, encouraging discovery learning, exploration and a flexible mind. While SMT skewed towards the formalistic view, under the value of control, as if exchanging creativity for rote learning and model answers.

In our case study, the PMT is inclined to relational learning, given the syllabus schedule less tight, teachers could help relate different learnings across the curriculum. While SMT highlighted instrumental learning, where rules and operations acted as the tools for practices and solving problems accurately and faster. PMT valued relevance to life and fun to nurture young minds. Teachers used daily life scenarios to pose questions and make the learning close to student's life. However, in the secondary school setting, the value gradually shifted to theoretical, from properties of different 3D shapes to applying an algebraic formula to solve equations. All these associated with the value of achievement (in examination) and control, implying a diminishing relevance of math in daily life.

In addition, PMT in our case study was accessible to all types of learners. Critical thinking training treated students equally, regardless of their learning ability. However, in SMT, questions in advanced level requiring a high order thinking gradually turned mathematics teaching to the value of special and for bright students only. Mathematics education would gradually become more discriminating when there are learning differences among students.

Both primary and secondary teaching in our case study shared the values of evaluating and reasoning, recognizing the importance of not just concepts and workings, but also how to reason the logic and convey their ideas effectively in a mathematical manner. Table 3 below tabulated Seah & Bishop (2000)'s mathematics educational values manifested in primary and secondary schools in this study.

Table 3: Mathematics educational values manifested in primary and secondary schools

Mathematics educational values	Primary	Secondary
1. Formalistic view – Activist view	Activist (flexibility, exploration)	Formalistic (control)
2. Instrumental understanding/learning – Relational understanding/learning	Relational (coherence)	Instrumental (practice)
3. Relevance – Theoretical knowledge	Relevance (fun, relevance)	Theoretical (achievement, control)
4. Accessibility – Special	Accessibility (critical thinking)	Special (high order thinking)

5. Evaluating – Reasoning	Evaluating & Reasoning (coherence, relevance)	Evaluating & Reasoning (achievement, progression)
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Conclusion

Values in mathematics education are the deep affective qualities fostered through the school mathematics curriculum, which are also influenced by culture and context (Zhang & Seah, 2021). Present study provided preliminary results on the differences in mathematics educational values of primary and secondary mathematics teachers in Hong Kong. Despite the differences in teaching values and approaches, students' motivation and exploration are co-valued by the two teachers. Both teachers value the role of daily life examples in teaching mathematics, but they have different understandings of the relevance. The shift in values held by the two teachers indicated some cues as to how local education system face challenges in balancing today's societal expectations on students' academic performance and the cultivation of future STEM talents with high order thinking ability and creativity. We argue that when the values like “fun” and “flexibility” in primary teaching are not extended to secondary education, students' creativity and intrinsic motivation to learn math and pursue STEM career are undermined. Due to the small sample size, the findings should await further verification in a larger study before generalization. Yet, it is expected to serve as a springboard for investigating the value evolvement between grades and value differences between teachers and students. It also provided additional evidence that makes cross-cultural study in the future possible.

Acknowledgment

The work described in this paper was supported by the EdUHK Research Fund RG13/2022-2023 and partially supported by the Research Grants Council of the Hong Kong SAR, China (ECS 28609121).

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