WHAT WOULD THE MATHEMATICS CURRICULUM LOOK LIKE IF VALUES WERE THE FOCUS?

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For years, school mathematics curricula have been dominated by a focus on skills and techniques: to many students, mathematics is something you do, rather than something you think about, imagine, argue, or feel. But we also know that computer and hand-held technologies have made the learning and practice of many skills and techniques redundant and irrelevant. Thus, we hear students asking questions such as "why are we learning this?"

Nevertheless, parents, politicians, mathematicians and business leaders want students to study mathematics to the highest level. In addition, they want students to leave school feeling that mathematics is important in their lives and in society generally. Sadly, it is the affective reaction of dislike of mathematics in school that many people most remember (Clarkson, Bishop, FitzSimons & Seah, 2000). We certainly do not want to argue against the importance of mathematics; nor do we want to see mathematics become less significant in the school curriculum. Our concern is that parents, employers, students, and society in general, are being short-changed by current mathematics curricula. Our view, supported by our respective observations across Asia, Australia and Scandinavia, is that the number one reason for the dislike, fear, and even hatred of mathematics is probably not the nature of mathematics itself, but the way the subject is portrayed and presented by the curriculum and its associated pedagogies.

In this article, we propose a radically different approach to the current, typical "Western" mathematics curriculum—"Western" in the sense that its design draws inspiration from the United States or British approach of equipping students with concepts and skills for problem-solving. Such a curriculum can be seen not only in Australia, but also for example, in Ghana, Singapore, Taiwan and many other places. The alternative approach we explore here would focus on values, rather than on concepts and techniques. We bring together various perspectives to create a significantly different research arena. Through discussion of three cases of research on values in mathematics education, we explore this arena and develop questions for future research.

Why a new approach?

Given the significance of affective aspects of mathematics learning, we surveyed the range of educational objectives that are encapsulated in the affective domain of Bloom's taxonomy (see Krathwohl, Bloom & Masia, 1964). According to the taxonomy, lower-level affective variables such as interest and beliefs appear to be relatively unstable and prone to change, while values and valuing are the most internalised and stable. Thus, if we can guide the development of students' (and curriculum writers') valuing from whatever sorts of beliefs, attitudes and interests they possess, we should be able to better facilitate a more positive and productive view of mathematics learning, and also a more empowering and relevant approach to curricular reform.

We take values in mathematics education to be "the deep affective qualities which education aims to foster through the school subject of mathematics" (Bishop, 1996, p. 19), and which are reflected in "the convictions which an individual has internalised as being the things of importance and worth" (Seah & Andersson, 2015, p. 169). Values thus characterise individuals and, more broadly, their cultures. Operationally, values in mathematics education are tools that members of cultural groups use to define the relative importance of different attributes of mathematics and of its pedagogy.

The negative feelings that students have towards mathematics can therefore be understood as being due, in part, to a lack of pedagogical attention on what is being valued in mathematics education, or on the inappropriate values that are being promoted, often unknowingly and implicitly (Andersson, 2011a). This situation can be changed. Unfortunately, there is little understanding in schools, let alone agreement, of what "appropriate values" are. Indeed, there is little understanding about the idea of values in mathematics at all. Even if there could be agreement about values, and about their importance, squeezing their development into the current curriculum structures is very difficult [1]. Teachers say (quite appropriately) that there is no space in the current curriculum. So values are ignored, thought to be implicit, or believed to be somehow ingested through practising of mathematical techniques. They are considered, if at all, as "add-ons" to the more "important" skills and techniques. Furthermore, these add-on values are often those related to the ethical, civic, religious or moral values of the individual, rather than values that facilitate effective mathematics learning.

A new approach, in which values and valuing are optimised for learners' cognitive and affective engagement with mathematics, is an alternative place to start. Appropriate valuing of mathematics and of how it is best learnt and

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taught should foster positive feelings and a sense of well-being with regards to the learning of mathematics (Clarkson, Bishop & Seah, 2010).

To organise the rest of this article, we draw on Robitaille and Garden's (1989) different levels of curriculum:

- The *intended curriculum* is what is planned, organised, and structured, though usually not by teachers. This is the level at which most discussions about the curriculum take place.
- The *implemented curriculum* is what the teachers actually teach, and is a contextualised and personalised version of the intended curriculum.
- The *attained curriculum* is what the learners actually learn.

Using this structure we consider three sets of ideas. Firstly, we consider the values themselves, the heart of a new intended values-centred curriculum. Secondly, we consider how values and valuing might be expressed in the different kinds of pedagogies which teachers can use in their implemented values curriculum. Thirdly, we look at several ways in which values and valuing in the attained curriculum might be accessed and assessed. Each set of ideas will be presented with a case through which we show different ways in which a values focussed curriculum could be developed. We do not, however, envisage a universal and canonical values curriculum emerging, given that values vary from culture to culture. Hence, at the end of each case, we propose researchable questions for any future study of a values-centred mathematics curriculum. Our aim is to clarify the significant questions, rather than present generalised answers.

Case 1: The intended curriculum in Australian schools

For the intended curriculum, three types of values are particularly relevant: mathematical values, mathematics educational values and general educational values (Bishop, 1996). This breakdown brings some order into what could otherwise be an unwieldy list of values, although admittedly the boundaries between these value types are fuzzy. We concentrate on mathematical values and mathematics educational values in order to tease out some of the complexities of dealing with values in classrooms. A framework developed by Bishop (1988) suggests three complementary pairs of mathematical values (which we explain further in the context of Case 2):

- Ideology: *Rationalism* and *Objectism*
- Sentiment: *Control* and *Progress*
- Sociology: *Openness* and *Mystery*

This framework can be used to investigate values embedded in intended curricula. We comment first on the Australian mathematics curriculum of the 1990s.

Clarkson and Bishop's (2000) examination of the 1990s Australian curriculum found markers for both mathematics and mathematics educational values. They found some emphasis on *objectism, rationalism* and *openness*. However, the overwhelming finding was that values were only implied in the curriculum material and were far from being a central guiding principle of any of the documents examined. Statements relating to values appeared to be an afterthought, often positioned in introductory pages (see, for example, Board of Studies, 1995). Clarkson and Bishop found that teachers would often disregard such pages; teachers read what they see as the key components of the curriculum—the sections that outline what content needs to be taught at what year level.

The current *Australian National Curriculum – Mathematics* has four proficiency strands, namely, understanding, fluency, problem solving, and reasoning. These strands "describe the actions in which students can engage when learning and using the content" (ACARA, 2013, np), and hence can be considered a statement of the mathematical values that are being emphasised. The valuing of *objectism*, *rationalism* and *openness* is still clearly evident within the descriptors of these strands, as well as in the body of the document. Unlike the hardcopy documents of the 1990s, the 2013 curriculum documents are only published online. The strands and their explanation are found in the preliminary components of the package. Anecdotal evidence suggests that teachers do not pay attention to these add-ons. Like their counterparts in the 1990s, today's teachers are only interested in what needs to be taught, and when.

Although the form of the curriculum can be changed, the actions of teachers both in the 1990s and in 2013 suggest more fundamental changes to the intended curriculum are needed. Values need to be embedded and made explicit in sections of the documents where teachers look to find what they need to teach.

At present, mathematics curricula look very much the same in many different countries. They normally start with "number", which is also given the most emphasis overall. Measurement and spatial ideas soon follow, and later still, notions of statistics and probability. Algebra appears at the end of primary school or the beginning of secondary school as a continuation of generalised number ideas, and so on. This way of constructing a mathematics curriculum is sometimes disrupted. In two exceptions, societal contexts were taken seriously, leading to the content starting with spatial ideas in the indigenous schools of central Australia (Harris, 1991), and with relationships in northern Australian indigenous schools (Watson, 1990). Hence, mathematics curricula can start in different places; they are not immutable. However, we argue more radically that instead of starting with mathematics content, curricula can start with mathematical values, perhaps based on the three pairs discussed by Bishop. The content is not to be dismissed, but its logical flow would be attuned to the values considered important. The development of the intended curriculum would be seen as the interplay of values and content.

In the light of these ideas, we pose some exploratory questions:

- Are the value clusters developed by Bishop (1988, 1996) useful starting points for developing a different type of intended mathematics curriculum? Are they clear, interesting, necessary, and sufficient?

What others could (need to) be added?

- What would online documents look like if those parts of the intended curriculum that teachers access, took seriously the notion that mathematical values and mathematics educational values need to be consciously taught?
- Is the idea of "valuing" (verbs) more significant for teachers than "values" (nouns)? Which would be better in helping teachers envisage more easily possible ways of planning for and teaching the intended values/valuing embodied in their newly framed curriculum?

Case 2: The implemented curriculum in Swedish schools

In this case, we focus on valuing that is privileged in the implementation of the mathematics curriculum in Sweden. In particular, we examine four ways mathematics content is taught to students: using textbooks, rich mathematical tasks, project work inspired by critical mathematics education, and technological learning devices.

Swedish teachers rely almost exclusively on textbooks for their planning, and hence trust the textbook to fulfil curriculum objectives (Swedish School Inspectorate, 2010). According to Johansson (2006), textbooks are believed to support teachers in managing non-homogeneous groups, in enabling each student to work according to his/her previous learning and needs, and in following the curriculum. Students quietly solving textbook problems has become part of the culture of Swedish mathematics classrooms. Thus, it is interesting to wonder what values might be implemented through textbook work? Consider an analysis of students completing a "typical" textbook problem, focused on the mathematical content of percentage:

> Arthur has a pond with goldfish. One morning he discovers that a heron has been there. At the end of the week he has lost 40% of his goldfish and only 54 fish are left. How many fish did Arthur have at the beginning? (Szabo, Larson, Viklund & Marklund, 2007, p.123, our translation)

The only mathematical value portrayed in this task is that of *control*. Students who had cracked the code in these texts rarely reflected on the mathematical context of the problem. They treated the exercise as mechanical, did the expected calculations and moved on. It could also be argued that there is an implicit valuing of *rationalism*, since the students might need to argue that their chosen calculations were appropriate for the problem. However when asked about this particular task, students' comments were mostly non-mathematical (Andersson & Ravn, 2012, p. 316). For example, they wondered about the real life context of the problem: "How did Arthur know it was a heron and not another bird or animal?" "Why didn't Arthur prevent the losses instead of thinking of percentage calculations?" "How come he does not know how many he had from the beginning when he knows he lost 40%?" *Rationalism* was not an issue for the students: they focussed rather on the lack of *realism*.

The core purpose of rich mathematical tasks is to introduce key mathematical ideas to students in such a manner that they are challenging. Rich mathematical tasks are meant to be open-ended. If presented appropriately, they can initiate mathematical discussions and become a bridge between different mathematical topics (Hagland, Hedrén & Taflin, 2005). These problems might be created within an investigative landscape (Skovsmose, 2001), in which students are expected to take over the process of exploration and explanation, and hence develop competences through mathematical modelling (Blomhøj & Højgaard, cited by Blomhøj & Jensen, 2003). The following rich mathematical task is from a Swedish text:

> Lisa is buying ice cream cones and can choose from four different tastes. She wants two cones. In how many ways can she choose the ice cream? (Hagland, Hedrén & Taflin, 2005, p. 39, our translation)

These types of tasks can potentially promote values of *rationalism* (argument, reasoning, analysis and explanations), *objectism* (applying ideas, symbolising, presentation and use of data), *control* (mastery) and *openness* (demonstrating ideas, verifying assumptions and transparency of mathematical reflections and calculations). Depending on the level of student dialogue, they might reflect on the creative process and hence the possibilities inherent in mathematics (*mystery*).

Project work can open up new discourses with respect to mathematical content in societal contexts. In one project, students were asked to create newspaper flyers. The objective was for students to acquire insight in how "powerful numbers" could be used. The specific data used in the project came from the 54 articles included in the *Convention on the Rights of the Child* (see Andersson & Valero, 2015). The following task was created, based on inspiration from Critical Mathematics Education (Andersson, 2011b; Skovsmose & Nielsen, 1996):

> **Newspaper posters with mathematical argumentation**
> The task for you today is to work in small groups to create a number of newspaper flyers that attract peoples' attention, engages them, and arouses their curiosity, and engages their reflection and/or emotions—with mathematical content! The goal is to acquire insight in how powerful numbers can be used in advertisements and media contexts. There are 54 articles in the "Convention on the Rights of the Child." We invite you to choose the one that interests you most and focus on it. Search and find information addressing these special children—information you consider important and want all people at the school to learn about. You might want to start a debate; it might be positive information, or maybe information in the article that is not followed, or something else. Reflect on how to present the numbers to get the message on your news flyer expressed in the best way. (Andersson & Valero, 2015, Andersson's translation)

The mathematical values we identified in this project were *rationalism* (argument, reasoning), *application*, *control* (emphasising the power of mathematics), *progress* (individual creativity) and *openness* (democratisation of knowledge). The valuing of *application* might best be expressed through the voice of a student:

> First I thought, a whole day of mathematics, I can't do it; I just can't be there the whole day. But when I got there it was actually quite fun and now, afterwards, I read and look in the newspapers in a different way. So I actually learned something and that was really unexpected of a math day. (Petra, interview, October 13, 2009)

Turning finally to the use of technological learning devices, consider Sven, a mathematics teacher who wanted his year 8 (13-14-year-olds) students to work with fractions in a different way. He commented, "I can't understand why they are expected to do all these [textbook] exercises. There are so many much more fun ways to learn". The task he subsequently built was about making films with "A Personal Trainer". The students were asked to make instruction films where they showed how, and why, to perform the different stages in the fraction calculations. The students worked in pairs; one acted as a personal trainer and the other as a student, and then they changed roles in four different films. They had access to books, whiteboards, personal mobile phones, papers and coloured pens to make their short instructional films. This task promoted the valuing of *rationalism* (reasoning), *control* (mastery) and *progress* (individual and collaborative creativity).

So far in this section, we have shared some examples of the enacted mathematics curriculum in Swedish classrooms. It became evident to us that what is required in practice is a way to determine which and how mathematical concepts will be referenced in a values-centred curriculum. While it could be argued that mathematical concepts will be of considerable importance in the search for a values-centred curriculum, an important consideration is the extent to which any particular concept or activity stimulates or encourages a particular value. Uniting mathematical classroom learning activities and mathematical values gives us a vehicle for determining a values-rich enacted curriculum structure: a concept repertoire and a values field. The two dimensions need to be linked in such a way that each of the value strands can be developed across the mathematical concept spectrum (see Table 1). It gives us a way to determine which mathematical activities could be used to develop each value cluster. Thus, we have populated Table 1 using the items discussed above, positioning them in relation to the valuing that they each promote.

This discussion of the implemented curriculum prompts the following exploratory questions:

- What other mathematics pedagogic structures are there for developing values?
- To what extent do digital versions of textbooks facilitate or impede the development of values?
- How might teachers be supported in representing values and valuing in more deliberate ways in the designs of rich mathematical tasks and projects?
- What might a values-rich implemented curriculum structure look like? How useful might structures such as the one shown in Table 1 be?

Case 3: The attained curriculum in East Asian schools

At the heart of our concerns about values in mathematics education is how we can access and assess students' value orientations: what values are the students learning? How can we know that learners are learning anything of the values we have described above? Using the two-dimensional content/values structure to select, for example, rich mathematical tasks, as in the previous case, how do we then access learn-

Values \ Content	Number	Algebra	Measurement	Space	Probability/Statistics
Rationalism	Newspaper poster "Personal trainer"				Lisa's ice cream
Objectism					Lisa's ice cream
Control	Arthur's goldfish Newspaper poster "Personal trainer"				
Progress	Newspaper poster "Personal trainer"				
Openness	Newspaper poster				Lisa's ice cream
Mystery					Lisa's ice cream
Others *(application)*	Newspaper poster "Personal trainer"				

Figure 1. Table showing value strands and content crossover.

ers' understanding and practices of values? These questions are about the attained curriculum.

Traditionally, values have been accessed through observational and interview techniques (*e.g.,* Clarkson, Bishop, Fitzsimons & Seah, 2000; Chin, Leu & Lin, 2001). These methods are time-consuming in terms of both data collection and analysis. Classroom teachers often feel uncomfortable about conducting lesson observations and student interviews, let alone analysing the resulting data. How then can teachers monitor immediately what their learners are valuing, in order to optimise the growth of mathematical well-being?

The construct of mathematical well-being (Clarkson, Bishop & Seah, 2010) focuses on positive development and growth through using a stage model (Table 2). The model describes the end-state of what a learner "looks like" at each stage. The descriptors serve as useful "targets" for the development of appropriate valuing—appropriate in the sense that these values are expected to foster learners' affective affinity with mathematics learning (including engagement and self-efficacy), as well as to support the growth of learners' mental processing. For example, a teacher aspiring to promote a learner's level of mathematical well-being to stage 3 may plan pedagogical activities that develop in the learner an appreciation and enjoyment of mathematical activities "to the extent that there is an active seeking out of those activities, and their value relationships". The teacher might facilitate this development through explicit, strategic and creative teaching of values in the implemented curriculum. Preliminary discussions with teachers have shown that they are able to use the structure in Table 2 both to identify students' stages of understanding of values and also to determine appropriate activities (such as rich mathematical tasks) to help students progress to the next stages.

It may be evident that the mathematical well-being structure was inspired by Bloom's taxonomies of educational objectives. There are also resonances with other conceptions, such as Kilpatrick *et al.*'s (2001) mathematical proficiency framework, as well as de Corte *et al.*'s (2000) set of healthy mathematical dispositions.

The mathematical well-being model has great value, but it does not help teachers in specifically assessing learners' attainment of different values. In the 'What I Find Important [WIFI] (in mathematics learning)' study, we designed and validated an online questionnaire that not only allows for the identification of a learner's value orientations in mathematics learning, but also allows the collective values of groups of learners to be mapped. Through a series of Likert scale (Figure 1) and slider rating scale (Figure 2) items, learners indicate the extent to which their values are oriented towards the two extremes of each of 13 complementary pairs of values [2]. In particular, the 14 mathematics educational values are the "useful values" that students from different cultures had nominated in earlier research studies (*e.g.,* Andersson & Seah, 2012. Open-ended items are also built into the questionnaire to allow respondents to report values that might not have been represented in the questionnaire items.

The WIFI questionnaire was administered in three East Asian cultures (mainland China, Hong Kong and Taiwan) to assess what valuing mathematics students there had developed (in the attained curriculum). Seah, Zhang, Barkatsas, Law and Leu (2014) reported on questionnaire returns of the 1,386 11- and 12-year-old primary school students. Principal component analysis conducted on the 64 items in the first section of the WIFI questionnaire revealed that the East Asian students valued achievement, relevance, practice, communication, information and communication technologies and feedback. *Achievement* was valued most within each culture, although the extent to which the other attributes were

Stage 0: Awareness of mathematical activities, values not recognised
At this first stage, the learner is aware of mathematics, not as a coherent body of knowledge, but as a collection of activities. There is an awareness of the different nature of mathematics from other activities at school. Values are present but not recognised as such.
Stage 1: Recognition and acceptance of mathematical activities, values recognised
The learner recognises mathematics as a coherent set of activities, with values appearing in some of the different conceptual categories. The learner also feels comfortable in the mathematical learning context, although having a passive acceptance of such experiences and being disinclined to seek them out.
Stage 2: Positively responding to different mathematical activities and to different values
At this stage, mathematical activity invokes a positive response, developing feelings of self-confidence and positive self esteem. This reinforces the acceptance and worthwhileness of mathematical activity in general and encourages the pursuit of different values across the mathematical field.
Stage 3: Valuing mathematical activity in general
At this stage, the learner appreciates and enjoys mathematical activity to the extent that there is an active seeking out of those activities, and their value relationships.
Stage 4: Having an integrated and conscious value structure for mathematics
At this stage, the learner has developed an appreciation of mathematics, of how and why they value it, and where that valuing might lead them in the future. Values are articulated and prioritised personally.
Stage 5: Independently competent and confident in mathematical activity
At this stage, the learner is a fully independent actor on the mathematical stage. Sufficiently independent to be able to hold one's own in mathematical arguments at various levels, and having an awareness of how the various value systems of others affect their understanding of mathematics.

Table 2. Stages of learners' mathematical well-being.

Section A

For each of the items below, tick a box to tell us how **important** it is to you when you learn mathematics.

	Absolutely important	Important	Neither important nor unimportant	Unimportant	Absolutely unimportant
1. Investigations	☐	☐	☐	☐	☐
2. Problem-solving	☐	☐	☐	☐	☐
3. Small-group discussions	☐	☐	☐	☐	☐

Figure 1. Examples of the Likert-scale items in the WIFI questionnaire.

Section B

For each pair of phrases below, mark on the line segment to indicate how more important one phrase is to you in your maths learning than the other phrase.

If you mark in the middle, it would mean that both phrases are equally important to you.

Example (non-maths):

Watching a movie ___ _✓_ ___ ___ ___ Shopping

66. *How* the answer to a problem is obtained ___ ___ ___ ___ ___ *What* the answer to a problem is

67. Feeling *relaxed* or having *fun* when doing maths ___ ___ ___ ___ ___ *Hardwork* is needed when doing maths

Figure 2. Examples of the slider rating scale items in the WIFI questionnaire.

valued differed across cultures. The items making up the components of the values also varied according to culture.

Our observation and thinking about values and valuing in the attained curriculum led us to questions which we hope will push our collective thinking further. These include:

- What valuings have been useful in supporting classroom mathematics learning?
- How do teachers deal with instances in class when they and their students value different convictions?
- How can values, especially those which do not support positive cognitive and affective development in mathematics learning, be countered or "untaught"?
- How comprehensive is the mathematical well-being construct?
- What are the optimum teaching strategies that help students move to another stage of mathematical well-being?
- How comprehensive are the 13 complementary pairs of values assessed by the WIFI questionnaire?
- What, if any, are the values that are pan-cultural in promoting positive cognitive and affective development in mathematics learning?

Concluding notes

The three cases presented above provide a glimpse of what a values-centred mathematics curriculum could look like, at the intended, implemented and attained levels of the mathematics curriculum, drawing on examples from different countries. In particular, many of the activities we have described are already taking place in mathematics classrooms in many countries, not just those we have discussed. That is to say, values that promote positive cognitive and affective developments are already being enacted and instilled in mathematics classrooms, although it is likely that not all teachers are aware of them. The resulting effects on (mathematics) education remain implicit and unrecognised, as we asserted at the beginning of this article. Thus, to fully realise the vision of a values-centred mathematics curriculum, it is important to research and clarify relevant questions such as those posed at the end of the previous three sections.

Inevitably, we four authors hold various values and it is clear from our ongoing discussions that the strength with which we value particular attributes varies. One of us values *mystery* more highly than the rest of us, whereas two of us probably focus first on *rationalism*. However, this variation does not mean that other values do not come into play for each of us, despite the preferences we have. We are aware of the role of the values we each hold and, indeed, what we value has been and continues to be held up for examination by each of us. Thus, our valuings are not ignored but to a degree they are foregrounded and continue to inform our work. This attention to our values is what we would also want of colleagues who teach in schools.

Our belief in the promising role of values in optimising school mathematics education has brought us together to write this article. We have been interested to explore what a values-centred mathematics curriculum looks like. In the process of doing so through the three cases, we have identified questions which we hope colleagues will take up in their research. At the same time, we are aware that, as in all other writings in mathematics education and beyond, what is valued by the writers shapes what is privileged and what is silenced. Nevertheless, it is our common wish that researching these questions will facilitate teachers' emphasis on values in their lesson planning and delivery, thereby laying the foundation for conceptual understanding, problem-solving applications, and learner empowerment.

Notes

[1] Although it might be expected that an "alternative" curriculum such as the *International Baccalaureate,* which puts an emphasis on values, might offer something different, an inspection of the website and our own experience indicate that mathematics seems to sit outside their embedded overall values-laden approach.

[2] Bishop's (1988) six mathematical values, 14 mathematics educational values and Hofstede's (1997) six cultural value continua (*e.g.,* power distance, individualism)

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So the real social function of the humanistic intellectuals is to instil doubts in the students about the students’ own self-image, and about the society to which they belong. These people are the teachers who help ensure that the moral consciousness of each new generation is slightly different from that of the previous generation.

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