



School Mathematics Education: What is the Point?

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Introduction

Manitoba Education has just (Spring 2013) completed a review of the K-8 mathematics curriculum. The review follows the publication of and subsequent public responses to the results of the 2010 Pan-Canadian Assessment Program (PCAP). The average performance of Manitoba's grade 8 students on the mathematics portion of the 2010 PCAP placed them second last among all provinces and one territory. Standardized national and international testing can play a role in assessing the quality of a nation's or province's school mathematics education program. However, such testing usually assesses only what can be cost-effectively measured, whereas many of the things that really matter in education cannot. There is even a much more important challenge to giving results on standardized national and international tests too much weight: education is at its very core a matter of values – societal values. This makes a direct comparison between education programs across cultures and nations problematic, and many mathematics education scholars have given recognition to the cultural base of school mathematics education around the world (e.g., Bishop, 1988; Wong, Wong, & Wong, 2012). This essay will deal with the values question for school mathematics education by asking the very fundamental question: What is the point of school mathematics education? My argumentation goes along the lines of the concerns raised by Jacobsen and Mistele (2011):

Students exit mathematics classrooms often wondering, 'What is the point?' Parents communicate to their children the cultural acceptability of struggling with and not understanding mathematics, pointing out without concern that they never 'got it' either. Students routinely complete their school mathematical careers never realizing the significance of mathematics in understanding important social, political, and economic issues facing our communities and our world. This is a form of societal negligence that many educators, and others, recognize must change. (p. 555)

My intention is to provide what I would consider central ideas that any substantial approach to addressing the question "What is the point of mathematics education in Manitoba?" should give serious consideration. There are more ideas to be considered in addressing this question, but for reasons of space I will only focus on those that usually find less attention in the public and professional discourses.

Before I get to the main ideas of this essay, I want to clarify that I do not think that school mathematics education is one of the top priority issues that Manitoba faces/should face in school education. While this essay contributes - and thus continues - the public debate on school mathematics education, it will place the discourse in the larger context of why and to what end we educate in schools in the first place. I hope that this essay thus can contribute to moving the discourse on school mathematics education in Manitoba from a narrow focus on skill development matters to the larger question of what and how school mathematics education can contribute to the larger purpose of public education.

The purpose of a MASS Discussion Paper is to examine current opinion and evidence on a topic of current importance and relevance to educators. The main aim of the discussion paper is not to define a position, rather to foster a rich conversation and reflective dialogue which will inform practice.

Discussion Question 1:

What kind of people do we want students to be when they graduate from a high school in Manitoba?

What role can and should school mathematics education play in enacting this mission?

Discussion Question 2:

What would mathematics education need to look like in Manitoba in order to prepare our students for life-long learning and citizenship in a democratic socially just and sustainable society?



Viewing School Mathematics Education as an Integral Part of General Education

What kind of people do we want students to be when they graduate from a high school in Manitoba? My sense - partially based on responses I have been receiving to this type of question - suggest that people's responses will be more like "being responsible", "being creative", "being a critical thinker", "being self-directed", "being able to live an independent life", "being happy", or simply, "being good people", rather than "being able to write a poem in pentameters" or "being able to solve quadratic equations". It is the concern for such general qualities of being a human and a citizen rather than specific academic competencies that characterizes the idea of "general education", which is an education that our society finds worth investing in because it is an education that is important to the development of all its young citizens and important to the development and well-being of our society. The idea of general education with such general, overarching goals for students is not unknown at all to public school education. A number of provinces articulate such general objectives in their public school acts, while in Manitoba those general objectives for general education can be found in Manitoba Education's mission for public education, which the ministry's website says is:

To ensure that all Manitoba's children and youth have access to an array of educational opportunities such that every learner experiences success through relevant, engaging and high quality education that prepares them for lifelong learning and citizenship in a democratic, socially just and sustainable society (<http://www.edu.gov.mb.ca/edu/mandate.html>).

That these are not empty words on a webpage can be seen in the focus and content of the Manitoba social studies curriculum (Manitoba Education and Youth, 2003) and in many of the initiatives by Manitoba Education.

What role can and should school mathematics education play in enacting this mission? Some mathematics education scholars, like Heymann (2003), see mathematics education embedded into the larger goals of general school education - a view that I take up in this essay. After first laying out goals for general education, Heymann proceeds discussing what mathematics teaching would need to look like, if it were to serve those goals of general education. Following this reasonable line of thinking, any society that envisions general goals for public education like the ones articulated in Manitoba Education's mission, will have to ask itself what role school mathematics education can and should play in achieving those goals. Thus, taking the government's mission for public school seriously, the central question arises **what mathematics education would need to look like in Manitoba in order to prepare Manitoba students for lifelong learning and citizenship in a democratic, socially just and sustainable society**. A response to this question will have to be curricular - concerning the learning outcomes for school mathematics education - and pedagogical - concerning students' learning experiences provided for by teachers.

Mathematics Education for Citizenship in a Democratic, Socially Just, and Sustainable Society

The notion of linking mathematics education with the broader public school objective of educating for citizenship in a democratic society has some traction in school mathematics education scholarship around the world - in North America (Ball & Bass, 2008), in England (Hannaford, 1998), in Denmark (Skovsmose, 1998), in Germany (Köhler, 1999), in Australia (Harris, 1998), and South America (Valero, 1999). Three of the central themes

of this literature are the following. **First, democratic education happens in mathematics class whether the curriculum and the teacher take note of it or not, it just might not happen with a desired impact.** So, better provide an appropriate curricular context, and approach the democratic experiences in mathematics classes in a prepared and deliberate way. **Second, mathematics education can provide a context for learning to reconcile differences - but only if learning opportunities are provided that allow for differences to immerse and to be explicitly discussed.** Experiencing mathematics as primarily a system of rules that need to be memorized and that lead to one right answer by using one specific method does not provide for such a context. **Third, teachers need to be prepared for mathematics education as democratic education. Many teachers and future teachers have learned through their own mathematics education to perceive mathematics and the teaching of mathematics as asocial, apolitical, and acultural.** Some mathematicians (e.g. Hersh, 1997) and many mathematics education scholars (e.g. Bishop, 1988; D'Ambrosio, 1994; Gutstein, 2006) have helped us see that doing mathematics is a human endeavour with all the qualities that come with any other enculturated intellectual endeavour: mathematics involves values (e.g. Hilbert's formalism versus Brouwer's intuitionism in the foundations of mathematics), emotions and spirituality (e.g. the Pythagoreans' number spirituality), cultural biases (e.g. formal school learning versus "*street learning*" of mathematical ideas and skills), historical changes (e.g., different views on the rigor of proofs in mathematics), creativity (e.g. the initially "*useless*" creation of non-Euclidean geometry), intuition (e.g. creating proofs in mathematics), etc. A corollary to this insight is the view that the teaching of mathematics needs to account for mathematics being a human endeavour rather than just a system of rules and procedures.

The link between social justice and school mathematics education has been quite prominent in the more recent mathematics education scholarship (e.g. Burton, 2003; Gutstein, 2006). **The link to social justice is generally discussed in form of two different kinds of concern. The first is the concern for equity in terms of access to high quality mathematics education for all students** (e.g. Atweh, 2011). However, "*high quality*" mathematics education does not mean the same kind of mathematics education for all students, it has to be high quality of relevant mathematics education - as the mandate of Manitoba Education also suggests. What kind of mathematics education is relevant will vary among students: Part of what counts as relevant is determined by the general goals of school education, and part of it is determined by students' interests and needs for their lifelong learning. The notion that high quality mathematics education prepares for university-based mathematics education is one of those still privileged cultural biases that have been leading to much dismay in school mathematics education (as I write these words, the federal government is reported to have warmed up to the idea of six trade colleges - including one from Manitoba - to offer trade college bachelor degrees equivalent to university bachelor degrees).

The second concern discussed in connection with linking social justice with mathematics education is about students' ability to "read the world mathematically" (e.g. Gutstein, 2006). **Reading the world mathematically means in this context that students use mathematical understanding to make sense of the state of affairs of the social context they are living in.** For instance, in what Jacobsen and Mistele (2011) have called "*Math for Social Analysis*":

Mathematical units are placed in interdisciplinary and social contexts encouraging critical analysis and connections to students' lives outside of school. Students study and mathematize issues such as mountaintop removal in Appalachia, gender bias in magazines, the distribution of wealth, and endangered species. (p. 559)

Discussion Question 3:

Reflect on the view that the teaching of mathematics is more of a human endeavor rather than a system of rules and procedures.

Discussion Question 4:

The type of mathematics education considered to be relevant will vary among students. Part of what counts as relevant is determined by the general goals of school education and part of it is determined by students' interests and a weed for their life-long learning.

How do schools in Manitoba view this balance?



Discussion Question 5:

What kind of mathematical experiences do teachers provide students that establish what mathematics is?

What are our educational goals?

Discussion Question 6:

Are subjects best taught in a more integrated way, assisting student to become better critical thinkers?

Discuss the evidence.

Learning to read the world mathematically, however, should not be misconceptualized as the idea of applying concepts one has first learned in mathematics class to “real life” problems. **Learning to read the world mathematically means that the mathematization of life problems is mathematics.** As in the discussion of the problem of transfer of learning below should make clear, the context in which students experience and use mathematical ideas and concepts is what mathematics is for them. So, it is the kind of mathematical experiences that teachers provide for students that establish what mathematics is for students. What we want mathematics to be for students is a question of our educational goals.

The following reference will allow me to clarify a few points concerning the linking of social justice issues and school mathematics education. Michael Zwaagstra, research associate with the Manitoba-based Frontier Centre for Public Policy and a Manitoba social studies teacher, is referenced as having said that *“having students apply their knowledge [of mathematics] to real-world issues is fine. But there’s a danger that shifting focus to social justice will come at the expense of teaching fundamental [mathematics] skills”* (St. Germain, 2012, p. 8). This view suggests that the ability to read the world for social justice using mathematical understanding is not a *“fundamental skill”*. I rather follow **the mission of Manitoba Education, which actually implies the need for such fundamental (mathematical) skills to prepare students as citizens for a socially just society. Such a view on what fundamental skills in mathematics are would also be more in line with the citizenship education that is at the core of the Manitoba social studies curriculum (see Manitoba Education and Youth, 2003).** Zwaagstra’s argument makes two additional assumptions that are in my view questionable: that there are so many basic skills in mathematics that there is no room within a 12 year school education to deal with *“mathematics for social justice”*; and that basic skills in mathematics cannot be developed within a social justice approach to mathematics.

Linking school education with the concern for a sustainable society has been happening fairly recently. I am not aware of mathematics education scholarship that inquires into this link. However, the scholarly literature on education for sustainability more generally (e.g. Sterling, 2001; Stone & Barlow, 2005) provides some general educational ideas relevant to any subject matter that wants to contribute to preparing students for citizenship for a sustainable society.

Two important ones are the following: to help students with whole systems thinking, subjects are best taught in a more subject-integrated way; and to help students become critical thinkers, which is central to ecological literacy, students should primarily learn through an inquiry-based approach. The implications for mathematics education are obvious.

School Mathematics Education for Lifelong Learning

The notion that school mathematics education can prepare students for lifelong learning is the idea that school mathematics education sets students up for continuous learning after graduation. Here I will discuss two concerns linked with this notion. The first concern is with students’ ability to use their mathematical understanding to support their general learning as they live their life. Take, for instance, the question whether I should pay into RRSPs or into a tax-free savings account for retirement purposes? Life problems from which to learn like this one do not come nicely packaged in separate book chapters so that we know what kind of mathematical ideas are appropriate to use.



Life problems relevant to our continuous learning are embedded in a rich and complex contextual structure, and we do need to have the competencies to understand the problem, to establish what (mathematical) tools are appropriate to use for this particular problem in this particular context, and to give consideration to the specifics of the particular context.

In an essay on the aims of education, the famous mathematician and logician Alfred North Whitehead (1929) has warned us about what he called "*inert ideas - that is to say, ideas that are merely received into the mind without being utilized, or tested, or thrown into fresh combinations*" (pp. 1-2). In more modern learn-theoretical terms, what Whitehead is warning about is learning that does not allow for transfer to new contexts beyond the narrow context in which a concept, a skill, etc. was learned and for which it was learned. For instance, learn-theoretical research suggests that having learned about a particular knowledge domain with understanding rather than by memorization will enhance one's ability to deal with problems from this domain in new contexts (National Research Council, 2000, pp. 55-56). Since "transfer between tasks is a function of the similarity by transfer tasks and learning experiences" (NRC, 2000, p. 73), learning school mathematics for life-long learning seems to be better supported through learning experiences in which mathematical ideas are embedded as they are when students do or will face them in their lives. An approach that promotes the learning of the basics in K - 8 mathematics schooling with the idea that those basics can then be "*applied*" in later years seems to be in conflict with what is known about the transfer of learning.

This aspect of school mathematics education's contribution to lifelong learning has some obvious implications for the mathematics curriculum and the teaching of mathematics, which, though, I have no room here to discuss. At last year's forum on school mathematics education in Manitoba, organized by Manitoba Education as part of its selective curriculum review, four student representatives were invited to speak on their views of mathematics and mathematics education. In response to the question where they are using the mathematics they have learned, all of them said that outside of school they are not using any of the mathematics they have learned in high school - or probably more appropriately, they are not seeing the opportunities in which they could use their mathematical understanding. Does (high) school mathematics learning create "*inert ideas*" rather than prepare students for lifelong learning? It seems to me that these kinds of data should concern us far more than Manitoba's relative standing in national and international standardized testing results.

The second concern linked to the idea of school mathematics education for lifelong learning is the concern for the adequate preparation for future formal studies in which mathematics is needed, be it university programs, college programs, or studies linked to work more generally. Mathematics - it is said and some posters in mathematics classrooms suggest so - is relevant to hundreds of jobs. Consequently, the argument then goes, students cannot miss out on mathematics learning in school. What this argument overlooks is that the question is not whether (high school) mathematics is relevant to most students' future learning, but what kind of mathematics and what kind of experiences with mathematics are relevant to their future learning. Almost all future mathematics learning building on school mathematics concerns applied mathematics rather than pure mathematics. The research on transfer of learning suggests that applied mathematics is best learned in the specific context in which it is to be used, but if the contexts for future mathematics learning are so various, what kind of applied mathematics are high schools to teach? Whose voices from work places or post-secondary studies are heard at the table where the high school mathematics curriculum is reviewed in Manitoba? This is a question about power, influence, and - as some would suggest - hegemony. The next section looks at these notions in the context of school mathematics education.

Discussion Questions 7:

Does high school mathematics learning create "*inert ideas*" rather than prepare students for life-long learning?

Discussion Questions 8:

What kind of applied mathematics should high schools teach?

Whose voices from work places or post-secondary studies are heard at the table where the high school mathematics curriculum is reviewed in Manitoba?



Discussion Question 9:

Should not all subjects be curricularly and pedagogically designed to support their larger purpose of Manitoba school education?

Discussion Question 10:

Does the current design of secondary school mathematics curriculum address the life-long learning need for students?

Does this suggest a hegemony of university mathematics over secondary school mathematics curriculum?



The Question of Hegemony

The notion of hegemony has been playing an important role in more sociologically oriented educational scholarship. The notion is to capture dominance, control, and power of some over important aspects of the lives of others, where the dominance, power, and control phenomena are so embedded into the culture and lived practices of the group that those phenomena are not normally perceived as dominance, power, and control relationships but are rather seen as a “*natural*” and “*normal*” part of the overall social life (on the notion, see, for instance, Apple, 2004). Proulx and Simmt (2011) draw on empirical and historical research studies to make the case for two hegemonies in the preservice education of future secondary school mathematics teachers. One of those hegemonies, they assert, is the taken for granted perpetuation of the practice in Canadian teacher education of having future secondary school mathematics teachers take courses in departments of mathematics for the provision of the disciplinary knowledge despite empirical evidence that seriously questions the value of such courses for school mathematics teachers, who need to understand mathematics differently - some suggest: who need to understand a different kind of mathematics - than, for instance, engineers, physicists, and research mathematicians.

This idea of a hegemony of university-level mathematics over school mathematics does not only seem to be relevant to the preparation of teachers, but also particularly to the secondary mathematics curriculum. Above I argued that in light of the role that school mathematics education can play for an adequate preparation for future formal studies, that there is quite a range of potential contexts for future mathematics learning. Considering this range, it seems very questionable that a secondary school mathematics curriculum can really adequately prepare students in a meaningful way for their respective future learning of mathematics. Whose mathematical interests are really served? Here are some of my observations. Of the three types of the currently offered secondary mathematics courses in Manitoba - the pre-calculus, the applied, and the essentials of mathematics courses - there is only one type that prepares for one and only one specific type of future formal studies in mathematics, namely the pre-calculus courses, which are designed to prepare students for university-level calculus. Using graduation and post-secondary data for Manitoba, I estimate that about 17% of Manitoba high school graduates will need university-level mathematics courses for their respective university-based program of study, but in 2010 it was twice as many students, namely about 35%, who were enrolled in grade 12 pre-calculus (using provincial examination data for that year). In a somewhat overstated conclusion, this observation suggests the following. **First, only 17% of Manitoba high school students receive a direct preparation for their future mathematics studies - namely those students who take university-level mathematics courses as part of their university program. Second, about the same number of Manitoba high school students take a series of mathematics courses - pre-calculus mathematics - that are designed to prepare them for university-level mathematics although they do not take university-level mathematics courses.** Whose lifelong learning needs for their future mathematics studies are served with the current design of the secondary school mathematics curriculum? Does this suggest a hegemony of university mathematics over secondary school mathematics curriculum?

What Is the Point of School Mathematics Education?

According to the provincial government’s mission, the general purpose of school education in Manitoba is to prepare students for lifelong learning and citizenship in a democratic, socially just and sustainable society. Should consequently not all subject matter teaching - which is still the way in which school education is structured - be curricularly and

pedagogically designed to support this larger purpose of Manitoba school education? If yes, the point of school mathematics education has to be to develop mathematical competencies needed for lifelong learning and citizenship in a democratic, socially just and sustainable society. Above I have discussed some of the curricular and instructional implications that such a view of the purpose of school mathematics would have.

Currently, such a vision for school mathematics education is neither properly reflected in the mathematics curriculum nor in the public debate on mathematics education in Manitoba. We have to move away from petty issues like whether particular algorithms should be explicitly mentioned in specific learning outcomes or not, and have to move to the much more central issue of how Manitoba Education's mission for public education can be stronger represented in the specific learning outcomes and the general learning goals for K - 12 as outlined in the mathematics curriculum.

Moving toward this vision, particularly two current phenomena in school mathematics education need to be tackled: first, the overcrowding of the pre-calculus courses with rather technical mathematical details; and, second, what can be called the “matryoshka effect” in mathematics education.

Anyone who ever taught pre-calculus high school courses knows that their curricula are full of technical details of mathematical ideas that leave virtually no breathing room for teachers to properly address students' power to think mathematically as citizens in and toward a democratic, socially just, and sustainable society. Matryoshka dolls are a series of Russian wooden dolls that fit perfectly into each other. As the largest doll encapsulates the second largest doll, and so on, so encapsulate the technical mathematical details of one pre-calculus course those of the next lower grade course, and then it moves from the pre-calculus courses to elementary school mathematics. Having been a high school teacher myself for years and now working with high school and elementary school mathematics teachers in Manitoba, this “I-have-to-prepare-them-to-be-ready-for-the-next-grade” syndrome is prevalent in particularly high school mathematics and impacts what and how mathematics is taught.

Addressing these prominent obstacles to getting to the point of school mathematics education, as a society we might need to accept a stricter separation of the core purpose of general education and the interests of particular university programs to offload the preparation of their future students to general education. In this context it might be worth seriously exploring the merits of graduation after grade 10 or 11 (as is the case in some sense in Quebec).

Are not most students generally ready at that time to move into more work or post-secondary programs related studies?

In light of this, what would really be the justification for general education at the grade 11 and 12 level? Does the current version of grade 11 and 12 general education with its focus on academic subjects not primarily benefit university-bound students, which in Canada make up less than half of the graduating students? **Particularly universities will have to play their part making such a vision for school mathematics education reality, but it seems to me that taking on the more program specific mathematics preparation of students is a small price to pay for higher education institutions if in exchange they get more mathematically competent citizens for a democratic, socially just, and sustainable society.**

"Our goal for all Manitobans is to have more mathematically competent citizens for a democratic socially just and sustainable society."

- T. Falkenberg

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Other essays with concerning issue that are related to school Mathematics Education in Manitoba can be downloaded from his professional website at:

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