Mathworks 12: A Critical Analysis of Text

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Concerned was an understatement; thanks to the incoming mathematics curriculum, I had to plan and execute at least four new courses, all with different mathematical mandates. "Don't worry," my principal assured me, "The new textbooks are foolproof. They will make teaching math easy." Mathematics education today relies on the textbook. According to Skovsmose and Penteado (2012), "the teacher can follow the textbook, and do so with good conscience, as the textbook is assumed to provide a recipe for good teaching" (p 74). Due to its integral role in the mathematics classroom, we must analyze the textbook and its purpose, pedagogy and power.

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Guiding pedagogical and curricular decisions, the textbook is not meant to solely control the curriculum. Textbooks are not written to replace a teacher—they are to be utilized and mediated by a teacher (Love and Pimm 1996). In fact, textbooks "provide a framework for thinking about what will be taught, to whom, when, and how," (Nicol and Crespo 2006, 331). The curriculum document and teacher should collaboratively develop this framework prior to filling in the frame with learner needs and the textbook. If the textbook is central to the construction of the classroom, teachers should make every attempt to analyze its reasoning and purpose before implementation.

MATH ON THE JOB

Lori Ann, Stefan, and René Regnier are members of the team at Blue Lagoon Organics that grows certified organic fruits, herbs, and vegetables on its farm near St. François Xavier, Manitoba. Stefan and René grew up in St. François Xavier, while Lori Ann was raised in Winnipeg.

The Blue Lagoon Organics team participates in a community-supported agriculture (CSA) system. Fifty-seven community members pay a yearly fee to receive regular deliveries of the farm's produce. To equally distribute the produce it grows, the farm team weighs it and divides it among the members. Lori Ann, René, and Stefan also calculate prices, create invoices, and work out ratios.

When distributing equal portions of produce to the community members, why is it not important that the weigh scale gives a correct weight?

The farm also sells produce to the general community on a price-per-kilogram basis. Give two reasons why it is important that the scale records the correct weight.

Lori Ann uses an electronic scale to weigh pumpkins before selling them to a customer. Weigh scales used to sell products on a price-per-weight basis must be regularly checked for accuracy.

Figure 1: *Math on the job (*Mathworks 12, *76)*

The Text to Be Considered

Throughout this paper I intend to analyze the purpose, pedagogy and power of the textbook *Mathworks 12* (Angst et al 2012a).[1] A specific focus will be made on the unit Limits to Measurement in *Mathworks 12*. Unique to the workplace mathematics pathway (also known as "dash 3") in the Western and Northern Canadian Protocol (WNCP) mathematics curriculum; this unit is not covered in the precalculus ("dash 1") or foundations ("dash 2") streams. The impact, ideology and authority of *Mathworks 12* all play a role in this textbook's curricular orientation.

Purpose

Producing a Good Worker

Mathworks 12 has a distinct mandate: to educate students in real-world mathematics required to succeed in the workforce. Since its students are destined to pursue trades, certified occupations or direct entry into the workforce, *Mathworks 12* addresses the curriculum through real-world contexts (Angst et al 2012b). For example, "Math on the Job" sections give students a sense of occupations requiring the mathematics they are about to learn, complete with a sample problem. The Limits to Measurement unit's job is an organic farm worker (Figure 1). Every effort is taken to ensure that students recognize the real-world basis of this job, including the location of the job, the place of origin of the workers and a specific explanation of what the work entails. Finally, students are asked to consider why they must record correct measurements with a direct relation to the price per kilogram—a good employee measures correctly. Another example to consider is a question on page 97, "What could happen if the tolerances for the door height or the location of the hinges were not followed?" At first these questions appear to offer mathematical reflection, but the "good worker" vantage point reflects the undertones of reinforcing proper workplace habits. If we cut the door outside the tolerance it will not close, and thus we produce unsatisfactory work. Both of these examples ask students to consider the impact of accuracy and tolerance in the workplace; substandard work is not affordable, nor is it acceptable. Anyon (1980) described working-class education as a means to retaining a good job. *Mathworks 12* supports this recognition that good workers receive good jobs, successfully placing its learners within the working class. Students not only need to be able to *do* mathematics but also recognize how it affects employability.

Mathworks 12 addresses the curriculum through real-world contexts.

An apparent goal of this textbook is to develop good workers, despite the claims of many theorists that education is not to be used for job training. For example, Dewey (1929) said "education … is a process of living and not a preparation for future living," (p 36). His reading of the situation is supported in literature such as Adler (2009) and his call to educate all students, not simply train the working class for jobs and educate the elite. Teaching workplace students to become "good workers" has implications far beyond textbook considerations and into societal concerns. Success in mathematics gives students the ability to climb our societal structure (Gates and Vistro-Yu 2003). *Mathworks 12* students are given the chance to succeed in mathematics, but not to the extent of the other pathways; thus, workplace (or dash 3) mathematics students are taught to be successful in their paradigm, as good workers.

Common Sense?

Mathworks 12 attempts to connect students' "common sense" to mathematics. Consistent use of concrete, real-world problems, such as the measurements of a stool (p 98), the time of a race (p 86) or the placement of patio blocks (p 97) clearly shows this intention. According to Polya (1985), accessing and unlocking students' common sense promotes mathematical exploration. However, many students struggle with the "common-sense" problems identified in *Mathworks 12*, particularly those who have not taken many practical and applied arts courses. According to Williams (2005), there is no such thing as common sense; everyone's sense comes from personal experiences. *Mathworks 12* assumes that students have a basic understanding of many real-world pro-

1. This work will be cited as *Mathworks 12* throughout this article to avoid redundancy.

cesses, most of which only some learners have encountered. Since the textbook is a single resource to be used in instruction, it can attempt inclusion through varying examples, but its reach is limited. The unit on limits and measurement relies heavily on an understanding of machinery, building or baking; a student who does not have these skills will inevitably struggle, unable to connect to the concrete example meant to ground the abstract mathematics.

Pedagogy

Investigative or Prescriptive?

Mathworks 12 could appear as investigative; it contains many activities intended to move beyond traditional drill-and-practise methods. However, these activities consist of specific steps for students to follow and data to collect (complete with sample tables). According to Smith and Stein (1998), higher-level mathematics processes include reflection on mathematics, require cognitive effort and suggest pathways to follow. While the tasks included in *Mathworks 12* offer students reflection questions, rarely do they require cognitive effort. For example, on page 83, students are asked a conclusion question: "State the precision and uncertainty of your measured times." A straightforward and direct application of the information being covered, this question does not move students to consider higher-level mathematics.

Mathworks 12 rarely asks cognition-provoking questions due to the method of activity execution: specific directions. Rarely, *Mathworks 12* students may be asked to develop a procedure; typically, students are consistently provided with specific directions on how to complete an activity. Directions are written in a clear and authoritative manner, ensuring an extreme amount of specificity so that students cannot deviate. According to Polya (1985), mathematics problems require four things: understanding what is required, identifying connections to make a plan, carrying out this plan and, finally, reflection. *Mathworks 12* students are not being asked mathematics problems, as they rarely have to develop a plan or reflect; rather, they are focused on reproducing prescriptive mathematics procedures.

The focus on prescriptive mathematics procedure could be because these students have been deemed "unsuccessful" in mathematics. In my experience, students in this pathway typically struggled with the "normal" mathematics classroom, but not necessarily the mathematics itself. Thus, these students are not part of the successful (or powerful) mathematics group. Students outside of the culture of power require specific instructions to succeed (Delpit 1988). If workplace mathematics students are not part of the power culture in mathematics, the author could possibly have interpreted this as a reason to provide specific direc-

b) To find the nominal value, add the maximum and minimum values and divide by 2.

$$\text{nominal value} = \frac{\text{maximum} + \text{minimum}}{2}$$

$$\text{nominal value} = \frac{0.250'' + 0.230''}{2}$$

$$\text{nominal value} = \frac{0.480''}{2}$$

$$\text{nominal value} = 0.240''$$

To find the tolerance, subtract the minimum value from the maximum value.

tolerance = maximum − minimum

tolerance = 0.250" − 0.230"

tolerance = 0.020"

Calculate half the tolerance.

$\frac{1}{2}$(tolerance) = 0.020" ÷ 2

$\frac{1}{2}$(tolerance) = 0.010"

The measurement can be written as 0.240" ± 0.010".

Figure 2: *Problem solution (*Mathworks 12, *94)*

tions to complete mathematical activities. Activities and projects in this textbook rarely reach into the investigative realm; thus, students are rarely taught to think, but are instead taught to follow instructions.

Order and Pacing

Linear in its framework, *Mathworks 12* follows a pattern common to most mathematics textbooks. Information is organized numerically (eg, unit 2 lesson 1 is titled 2.1) and presented in a sequential order. While teachers can choose to break this sequence, many new teachers often follow the textbook sequence provided (Nicol and Crespo 2006). In my teaching experience, students are frustrated by jumping around within the textbook content. Linearity in a textbook is a way of controlling time and sequence in the classroom; very few textual materials break linearity, and then typically only in the form of reference, such as answers in the back or using the margins to emphasize (Love and Pimm 1996). This textbook has linearity; in fact, the only writing within the margins is superfluous information or images one

PUZZLE IT OUT

MIXING CEMENT

Anil needs to add 4 gallons of water to a volume of cement that he is mixing. He has three buckets: an 8-gal one filled with water, a 3-gal bucket, and a 5-gal bucket. The buckets have only a "full" marking at their capacity, so he can only completely empty or completely fill a bucket to measure a volume. How can he divide the water into two equal 4-gallon portions?

HINT

The solution takes seven steps!

Figure 3: *Puzzle It Out question (*Mathworks 12, *87)*

could use to vaguely support the topic. This order and power is welcomed by students, as they prefer a familiar structure in their mathematics classroom. Again, conforming to expected work habits and rigid structure is required, further conditioning students into workers by limiting their mathematical thought and exploration.

Rigour

This textbook appears to be written for "lower-ability" mathematics students. According to Dowling (1991), "'working class' is part of what it means to be 'less able'" (p 148). As aforementioned, *Mathworks 12* students are equipped to enter the trades and/or workforce; these students are destined to become working class. Workplace-oriented mathematics textbooks are seen to be antiacademic and reinforce the importance of manual work (Dowling 1991). *Mathworks 12* focuses on developing good workers, seemingly due to their perceived lack of mathematical ability. Examples within this textbook always offer specific solutions; work is neat and down the page (see Figure 2). There is a plan shown in the steps (Figure 2), but the plan is only revealed as each subsequent step is completed, indicating that students should be planning their math work; it is more important that students learn to focus on completing proper procedures as the steps advance from correctly calculated values.

Workplace mathematics students are rarely given problems with more than one or two steps, but *Mathworks 12* does offer a few chances to move into higher-level tasks. The most interesting activities for students have varying solutions, such as the "Puzzle It Out" questions. For example, in the Limits to Measurement chapter, students are asked to split eight litres of water into two sets of four litres each (Figure 3). Finally, students can move into Smith and Stein's (1998) higher-level demands of planning, representation and cognition-activation. Students are asked not only to solve the problem but, more important, also to share *how* the problem can be solved. However, the authors anticipate that students will have difficulty with this open problem and thus offer the helpful hint bolded in the margin. Immediately, learners may feel limited to these seven steps. Workplace mathematics students are rarely offered the opportunity to independently undertake rigorous mathematics, presumably because of their alleged ability or lack thereof.

Power

Authority in the Classroom

According to Love and Pimm (1996), teachers and students reorient themselves according to the ideas presented in the textbook. Consequently, the textbook is given an unprecedented amount of authority; this is strongly utilized in *Mathworks 12*. For example, in an attempt to elicit knowledge, *Mathworks 12* questions students "What assumptions do you make?" (p 78); unfortunately, solutions are typically printed immediately following these questions. Students' learning (and thus thinking) is directed onto a specific path—the correct path as defined by the textbook. Ensuring that students follow specific, laid-out steps throughout activities (such as in Figure 4, overleaf) to find the correct solution further reinforces the power of the textbook. Many mathematics texts are "closed texts": there is a determined and fixed way to complete each problem and readers' steps are confined to this process (Love and Pimm 1996). Closed correctness gives the textbook an air of authority—it alone contains accurate solutions. Textbooks hold the correct solutions and thus determine the norm in learning mathematics (Delpit 1988). Defining the normative system forces students and teachers to reorient and submit to the power of the textbook.

What to do:

1. Examine a toy block. Decide which dimensions of the block should be reviewed for quality control.
2. Make a sketch of the block showing the front, side, top, and bottom views. Label the critical dimensions with letters.
3. Make a quality control table with a column for each critical dimension and enough rows to measure at least 24 blocks. Your table should include length, width, height, outer nib diameter, inner hole diameter, the position of the nubs and holes with respect to each other, and any other dimensions you think are important to the quality of the product.
4. For each of the 24 blocks, make and record the dimension measurements.
5. Find the maximum and minimum values of each dimension. Based on your investigation, what is the tolerance for each dimension? Write each critical dimension in the form nominal value ± $\frac{1}{2}$(tolerance).

Figure 4: *Specific directions (*Mathworks 12, *99)*

Language

On page 76 of *Mathworks 12*, students are told, "You will explore the concepts of accuracy, precision, uncertainty, and tolerance." The use of *you will* is prevalent in *Mathworks 12.* "Addressing the reader as *you* may indicate a claim to a relatively close relationship between author and reader or between reader and subject matter" (Morgan 1996, 6). The appearance of a personal relationship lessens the necessity to submit to the textbook, yet still indicates the necessity to surrender one's authority. The use of the indicative *you will*, again, gives authority to the textbook; the textbook gives direct instructions to students of what learning is to be achieved, and students are required to yield to these demands.

The textbook uses *you will* in an attempt to imply a personal relationship; yet when undertaking mathematical instruction, it uses authoritative and aloof language. There is no relation to the author or the student, merely a relationship with mathematics. The solution to the example in Appendix A uses phrases such as "the measurement is shown …," "the uncertainty of the measurement is …" and "in this case, the measurement precision and uncertainty are not clear." According to Morgan (1996), the use of this reserved, neutral voice creates a formal relationship. The author has decided to shift between an informal and formal relationship with the reader, but the important aspect is *when* this shift occurs. The reader is addressed formally when the reader is invited to solve mathematical questions; yet, when students are being instructed, informal language is used. Thus, the textbook becomes the expert for the student and for mathematics as the ultimate authority.

Concluding Thoughts

As illustrated by Nicol and Crespo (2006), Love and Pimm (1996) and Skovsmose and Penteado (2012), the mathematics textbook is central to instruction. Thus, mathematics educators and educational researchers are called to analyze the textbooks used. This article has analyzed and criticized the purpose, pedagogy and power of *Mathworks 12*. The purpose of *Mathworks 12* appears to be to produce good workers, successfully driving social reification. Commonsense math is also a focus of this textbook, but the common sense addressed is not always common; this assumption of commonality could alienate students further from mathematics. Pedagogically, this textbook is prescriptive: students are given specific steps for doing mathematics. The linear pacing of this textbook contributes to a restrictive learning of mathematics, most likely due to the perceived lower ability of these students, resulting in a textbook with little rigour in instruction. Finally, *Mathworks 12*, through the use of both formal and informal language, strongly employs authority over its readers; the authors appear to have designed power structures of "textbook over student" and "mathematics over all." Teachers must be roused to the impacts of mathematics education on our world (Kumashiro 2009). Textbook analysis can bring this awakening, as shown by the investigation into *Mathworks 12*; after analysis, teachers may be able to truly consider the impact that texts have on their students.

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