Working Group 13 Report: Textbook Design in Mathematics Education

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Executive Summary

The Textbook Design Group focuses on the identification of the key design elements that make a math textbook instructional and accessible for all readers. The Working Group includes parents, teachers, educators, instructional designers, ministry of education staff and publishers. The group has had two working sessions at the Field's Institute's Math Education Forum, a number of informal meetings, email exchanges and four days of meetings at CMEF (Canadian Mathematics Education Forum) in May 2009.

Parents and some educators provided the following list of key design elements for a textbook:

- The core instructional resource, commonly called a textbook, must be self-contained. No supplementary resource, such as an instructor's manual, solutions guide or workbook should be required for the reader to understand the concept, work though an example, and have an opportunity to practice the lesson at various levels of difficulty. Practice questions for higher level learning that require analysis and synthesis should provide one or two suggested solutions.
- Instructor resources, such as additional problems for testing or class discussion should be independent of the textbook.
- Textbook should not contain rhetorical questions that do not offer possible solutions or procedural questions that do not provide a solution
- Textbooks should be light for ease of carrying
- Since children develop intellectually at different rates and since the school system is age-based, many children will be out of step with classmates on one or several topics in the math curriculum. Primary to secondary math textbooks should be published as topic booklets to allow students to learn at their own pace and level of understanding.
- Textbooks should review concepts from previous topics to bridge possible gaps between sections/chapters
- Graphics or photos should be
    - Simple
    - Mathematically correct
    - Relevant to the target student audience

K-12 teachers and university teachers tended to differ in their perception of the role of a textbook. During the CMEF conference, K-12 teachers regularly spoke of strategies to pull instructional material from several sources. Textbooks were referred to as only one type of resource. One middle school teacher stated in the presentation "I have to admit, I did use the textbook from beginning to end in my first year, but I don't do that anymore." K-12 teachers generally wanted the control of instruction to be in their hands. Many, for instance, did not want the answers to problems or strategies for problem-solving to be in the textbook that students received.

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Publishers of K-12 texts see teachers as the purchase decision-makers and follow their lead in deciding what goes in a textbook. The curriculum revision process gives publishers less than a year to design, develop and publish a math textbook for the K – 12 market. Publishers do not have adequate time to provide several examples, practice exercises, or detailed explanations of all concepts. Most K-12 math textbooks have numerous reviewers and contributors (often 20 to 30) who are often given little time to provide feedback or guidance because of the rush to publish imposed by the ministries deadlines. To paraphrase one elementary school principal, "I have been through that; a bunch of us are crammed in a hotel room for a few days and have to get through everything."

The university market is markedly different than the K-12 market in how math textbooks are written, designed, published and used. University professors report taking five to seven years to test and revise material for a textbook. In most cases, the math textbook for the university market is written by one or two professors who may be assisted by others for such tasks as developing answers for practice questions. Publishers provide editorial, graphic design and marketing support. Though not explicitly acknowledged, publishers of university textbooks sign on authors who have a sufficient number of students to cover the cost of production within two years.

University teachers tend to use a textbook as the foundational tool for the course. Several university teachers in the group expressed frustration that students do not know how to use a textbook and they were surprised that many students have never used a core resource to work through the curriculum – they have had 13 years of handouts.

Background

The Textbook Design Working Group was formed by parents and educators who were dissatisfied with the textbooks that were published for the public school system and universities in Canada. For parents, homework was stressful because they did not always understand what was required. Teachers, especially elementary school teachers, often found the instructional material equally confusing. The university professors within our group have been primarily concerned with instructional design and mathematical accuracy in the content and graphics of math textbooks.

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Activities

The Working Group's activities have included a series of informal surveys, two working sessions at the Ontario Math Education Forum[1], email exchanges of members of the group and a three day meeting of the working group at the Canadian Math education Forum 2009 Conference in Vancouver[2].

The Ontario Ministry of Education staff made presentations at the Ontario Math education Forum about the curriculum development process for K – 12 in Ontario. Representative of four textbook publishing firms (Pearson, Nelson, Wiley and Holdfast) were active participants in the Vancouver meetings.

This report summarizes the trends and issues identified to date from these activities.

Role of a textbook for each stakeholder group

There are at least five stakeholder groups in mathematics education:

1. Students
2. Parents
3. Teachers
4. Ministries of Education
5. Publishers

1. Students:

No students have participated directly this far in the Textbook Design Working Group. Based on parent comments, students who understand the material and understand the teacher's instructions do not tend to talk about math or involve their parents in their homework.

> *Sample comment: He doesn't ask for help. He's doing OK in math so I guess everything is fine*

The home experience of students who do not understand their math homework is markedly different. Parents describe fits of hysteria and crying of both children and parents, primarily because neither the child nor the parent has a clear understanding of what is expected. The principal of an elementary school, who is also the mother of two children under 11, reported disagreements at home about math homework primarily because the expectations for the homework were not clear.

[1] The Working group is indebted to Miroslav Lovric who convinced the Forum's Steering Committee to devote two sessions for the Textbook design Working group to draw upon the expertise, experience and opinions of the members of the Math Education forum.

[2] Peter Taylor gave this group a voice by accepting our proposal to participate in the Vancouver meetings.

2. Parents

This Working Group was initiated was the exasperation of parents with children who have not been well served by the math education system in Ontario. Hence, the group has a problem at its core: children are left behind in mathematical understanding year after year within a system that assumes that moving on to the next topic is in every child's best interests.

The contribution of the parents was to state the problem with math education:

- The education system is based on age rather than stage of cognitive development. Some children are always in a math class that is beyond their cognitive development. A child who struggles with basic arithmetic in Grade 2 is pushed on and the lack of understanding accumulates each year. This child seldom 'knows what the teacher wants'. The behavior seen by parents includes hysteria, anger, rebellion, depression and withdrawal.
- Homework assignment often lack clarity and context
- Parents have inadequate access to resources that they can use to help their children at home
- Few elementary school math textbooks are easy to understand. The 'Big Idea' is often presented as a rhetorical question without context or practical direction.
- Teachers are often afraid of math and take a defensive stance before parents
- Elementary school teachers who are not well educated in math, teach inaccurate concepts that they insist the children accept (E.g. parent shows a child that a square is a form of rectangle and the child loses mark in a test when a square is identified as an example of a rectangle)

3. Teachers:

Many elementary school teachers fear math and would rather a math specialists teach the subject. During the sessions, many elementary school teachers expressed fear of being assigned math and told stories of math phobia. There were reports of the teachers being confused by the curriculum, the instructional aids and the study aids. Fear of math among teachers is not universal, but it came to almost an expected introductory comment (" I was never good in math and then in my first year I had to teach it…"

During the CMEF meetings, which were attended by at least 20 K-12 teachers, there was a unquestioned assumption in the open sessions of 150 attendees that relying on one textbook was not the desirable way to teach. Teachers expected to build a lesson plan from copies of exercises and instructions from a variety of resources.

It appeared from the comments from teachers that a good teacher uses more than a textbook, that the confusion expressed by parents that the work brought home was confusing and lacked context was a part of an intentional strategy to 'be a good teacher'. Though not explicitly discussed, the undercurrent of comments from K-12 teachers was that a 'good' teacher does not rely on a textbook.

4. Ministries of Education

For K-12, the Ministries of Education in each province are responsible for the curriculum. The Working Group has had limited representation from these ministries. The group did hear a presentation from the Ontario Ministry of Education, but no government staff attended the Textbook Working Group at the CMEF meetings.

5. Publishers

Five textbook publishers were active participants in the CMEF meetings and four attended the meeting of the Textbook Design Working Group.

Most of the input from the publishers focused on the K-12 sector. One publisher noted that it takes five years to get a textbook 'right'. That luxury appeared to be limited mostly to the domain of the university textbook.

The publishers present said that the teachers are the main influencers in the purchase decision and that teacher wanted four-colour textbooks. When asked why textbooks aren't light-weight (easier for a child to carry) or two colour (less expensive), topic-based shorter books (allows for different math groups within the class as sometimes occurs in reading classes), the publishers said they have to respond to the influencer, the teacher, and the competing publishers.

Textbook Design Issues for K-12

- Parents want
    - Textbooks that are effective in the absence of a teacher
    - Clear instructions with examples
    - Many opportunities to practice with solutions provided
    - Textbooks that have been reviewed and extensively usability tested
    - Books that are not too heavy for the children to carry
    - Individually produced modules for each topic stream, so a student who is at one grade level in one stream may study at another grade level in a different stream
    - More open market for approval of accepted textbooks
- Publishers want
    - Ability to bid on a custom publishing order under a long-term contract with guaranteed sales
- Teachers want
    - Control of problem solutions
    - Text that guides the underprepared teacher

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Textbook Design Issues for Post Secondary Education

- Publishers would like:
  - Consensus on what makes up a first year post secondary math curriculum
  - To help publishers deal with the complaint about the textbooks being too big
  - Change in perspective among profs about extensiveness of content included
    - Textbook should not be expected to contain all the resources
  - Openness of profs to non-text modes of delivery
  - Profs to be trained in how to use a textbook
  - More information on what supplements profs use
  - Clarity of what each market segment wants and needs
- Profs want
  - Common elements and common design from secondary
  - Continuity in curriculum from secondary to post-secondary
    - Challenge: Courses are streamed e.g. 5 calculus 1st year courses at McMaster (Engineering, Life Sciences, Business, 3 at Brock
  - On-line resources
    - PowerPoint's
    - on-line version of the text that the profs can cut and paste sections
    - solutions manual for students
  - Multiple approaches
  - One voice – single author

Summary

The Textbook Design Working Group is a work in progress. The comments and observations made in this report are anecdotal. There is a need for rigorous research to substantiate or refute the conclusions of the Working Groups members.

This working group has identified sectors of dissatisfaction in the instructional design of mathematics textbooks. Within the K-12 sector textbooks appear to be hurriedly produced in response to government curriculum development cycles that allow only a year for textbook design, curriculum development and publication. Within the university sector, professors lament the lack of preparation of student with using a textbook as a primary source of information. Within the Working Group, it is the university professors who are primarily interested in the core topic of the instructional design of textbooks. During the CMEF meeting, the critical topic of instructional design did not receive the attention it requires.

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Next Steps:

- Increased work on the most effective instructional design approach for mathematical textbooks
- Promotion of concerns of parent, teachers, and publishers of the curriculum development process across Canada in the development of mathematics textbooks

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