An Analysis of Question Types in a Workbook for Mathematics 10C

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In this article I analyze the *Foundations of Mathematics and Pre-Calculus Grade 10 Workbook (for Math 10 Combined)*[1] (2010) and focus on the philosophy of mathematics education as presented in the Alberta Grades 10–12 Mathematics Program of Studies (2008). I completed this analysis to satisfy my curiosity about whether using a workbook to plan from, teach from and learn from would completely reflect the intent of the program of studies.

I have used a workbook by the publisher of *Foundations* for a previous mathematics program of studies. I found that workbook designed more for a drill-and-practice type of classroom than an investigative and understanding-building classroom in which students contribute to knowledge generation that would be reflective of the 2008 Alberta program of studies. According to Silver et al (2009), "the adoption of new curriculum materials, especially those designed to embody innovative ideas and practices, can catalyze changes in teachers' instructional practice and enhance students' opportunities to lean mathematics" (p 245). I am not positive that *Foundations* will be representative of innovation in teaching or of enhancing students' experiences in mathematics learning. In my analysis, I consider how well *Foundations* reflects the program of studies with respect to allowing for and expecting individual representation of knowledge and understanding.

Program Philosophy

The philosophy for mathematics education of the Alberta Grades 10–12 program of studies (2008) centres on individual differences in students. Students should be encouraged to develop their own understanding of the mathematical concepts and their own personal strategies for solving problems and answering questions. The front matter of the program of studies refers to students "taking intellectual risks, asking questions and posing conjectures" (p 2). I feel that a major change in the program is in allowing students to express their mathematical understanding in their own way and "that it is acceptable to solve problems in different ways and that solutions may vary depending upon how the problem is understood" (p 2). Many teachers have previously taught that there are only one or two acceptable ways to solve a problem or approach a task. The change in focus from the teacher being the giver of knowledge to the student being the creator of knowledge may prove to be challenging for some teachers. In my experience as a high school mathematics teacher, I have struggled with stepping back and letting my students create their understanding; I anticipate that other mathematics teachers will experience similar struggles.

Allowing students the freedom to create their own solutions and use their personal strategies in approaching problems was a major focus in my analysis of *Foundations*. My analysis centred on how the lessons and activities in the workbook demonstrate that the creation of knowledge and the use of personal strategies by students is valued and expected. I have been working closely with the program of studies over the last couple of years, and I believe that one of the most important features of the program of studies document is the front matter. Unfortunately, I suspect that teachers often pass over the front matter to focus on the specific outcomes, not on the philosophy of mathematics education that the program was built on.

Format of the Workbook

Foundations is organized into ten chapters, each consisting of seven to twelve lessons of which the last in each chapter is a practice test. Each lesson follows a similar pattern: class examples for the teacher to go through with the students, a set of assignment questions on the lesson and an answer key for the assignment questions. The lessons may also have other components, such as definitions, references to previously learned material and previous lessons in the workbook, how to access certain features on a calculator, warm-up activities and investigations. Several of the lessons include an "Extension" section that introduces students to material that is beyond the

scope of the program of studies and sets out practice questions on the extension material. The "Assignment" section of each lesson contains a variety of question types that include short answer (or completion questions), long answer, true/false, matching, multiple choice and numerical response.[2] The practice tests at the end of each lesson include multiple-choice, numerical-response and written-response questions.

Foundations is designed so that teachers use the examples provided, and students copy down the answers that the teachers give. There is room in the workbook for students to write their solutions to the questions. At the end of each lesson and each practice test there is an answer key for each of the assignment and practice test questions. Answers, but not the worked-out solutions, are provided for the questions in the workbook; the solutions are provided in a separate solutions manual that the students can purchase if they choose. The solutions manual is a condensed version of the teacher's manual. Both manuals provide a solution to each of the questions.

What I noticed in previous versions of *Foundations* is that the teacher and student solution manuals provided only one method of completing a question. Teachers often followed this solution regardless of what might be best for their students. When I have used my professional judgment in class and have strayed from using the method demonstrated in the solutions manual, students question me, stating that what I have done is not in the book and, therefore, it is not correct. According to Christiansen and Walther (1986), teachers need to respond to their students and their students' needs and also to the principles of pedagogy that the teacher believes in. This type of manual may stifle teacher and student creativity, present one correct way to do math and take the decision making out of the teacher's hands.

Method

Foundations is organized into sections titled "Lessons," "Assignments" and "Practice Tests." Approximately 36 per cent of the pages in *Foundations* contain lessons, 48 per cent contain assignments, 9 per cent are practice tests, 5 per cent have only answer key content on them and 2 per cent of the pages are blank. I analyzed 33 pages (approximately 5 per cent) in *Foundations*; each section was represented proportionally in the sample. I used a random number generator (www.graphpad.com/quickcalcs/randomn1.cfm) to generate 55 numbers to represent page numbers in the workbook to analyze. I used 54 of the generated numbers, because 5 of the generated numbers were repeated in the sample, 4 corresponded to answer key pages, 1 was blank, and 14 were skipped because they corresponded to sections that already had enough pages in the sample. In the selection of the pages analyzed, 14 of the pages were from lessons, 18 were from assignments and 3 were from practice tests. Two of the pages contained both lesson material and assignment questions and were therefore counted in each category and included in the count for both lessons and assignments above.

The goal of my analysis was to see how the material presented in *Foundations* reflects the philosophy of mathematics education in the 2008 Alberta program of studies as presented in the previous section. I focused on the words that were used when eliciting a response to a question in the three different sections of the workbook as listed above. The questions that were posed were either for the teachers to use as examples for students or for students to answer as a part of an investigation or an assignment. I also considered the material that was provided in the lessons that was either used as an explanation or definition of a concept or process. I broke down the questions that I saw in *Foundations* into five categories: (1) instances where students/teachers are asked to explain, describe or state a rule, (2) instances where the method to be used to solve the problem or answer the question is given, (3) instances where the method to be used to solve the problem or answer the question is not given, (4) instances where alternate representations are given or expected as a response and (5) instances where a unique question is asked or a unique response is expected.

The focus in my analysis is to consider how *Foundations* encourages students to consider alternative methods of approaching problems. I wondered if the style of the questions in *Foundations* would encourage students to explore, think critically or consider alternative solutions. This query arose from my experience with a previous workbook produced by the same publisher. The following sections contain the details of my analysis, broken down by *Foundations* section and expectation, and a conclusion based on the analysis.

Lessons

As mentioned previously, *Foundations* contains ten chapters consisting of several lessons each; 14 of the 33 pages analyzed were from lessons. The letter that accompanies the workbook states that "the class examples are designed to be teacher led" and that "each unit contains some exploration or investigative work which allows students the opportunity to develop new mathematical techniques or formulas."

After reading this I was eager to see how the exploration and investigation were handled in *Foundations*.

The results of my analysis of these 14 pages with respect to the categories of questions asked are shown in Table 1 below.

Of the 41 instances of questions or directions, I consider that only 5 asked the students to "communicate and reason mathematically" (Alberta Education 2010, 2). According to the philosophy of the program of studies, I would expect that one focus of instruction in the course would be to have students communicate and explain their understanding of the concept. What I found most interesting is that approximately 46 per cent of the instruction expects teachers and students to complete questions or tasks in a specific way. Of the 14 pages analyzed in the lesson category, none contained an investigation, as was mentioned in the *Foundations* supporting materials. Nor did I see any questions engaging the students in discovering mathematical concepts for themselves.

I do understand that a large portion of examples specifically mention a method of solution because that particular method is taught in that lesson, and therefore the students need to have exposure to that method. I saw very little opportunity in these lessons for students to take risks or think and reflect independently (Alberta Education 2010). Even in the cases where the specific method was not given for completing the task, the method was implied by the lesson that included the task.

One example, on page 530, asks for an analysis of student work where at least two of the three solutions are incorrect. The errors in the provided work are to be described and the correct answer is to be found. I appreciate this type of question because it gives students an opportunity to think about solutions and analyze possible errors. This skill is necessary for students to reflect on their own solutions and possible errors. I found only two other instances in the pages analyzed where students and teachers are expected to describe and think about what they are doing and why.

Table 1

Category	Number of Instances	Examples
Instances where students/teachers are asked to explain, describe or state a rule	2	"Which of the calculations above is the easier method for..." p 94 "Explain each of their significance ..." p 477
Instances where the method to be used to solve the problem or answer the question is given	19	"Convert ... using ..." p 145 "Write ... using ..." p 101 "Use ... to ..." pp 7, 94, 477, 540 "The method of ... can be applied to ..." p 358 "Estimate mentally ... use a calculator to find ..." p 25 "Complete" (part of the solution is already given) pp 63, 599 "Evaluate" (part of the solution is already given) p 94
Instances where the method to be used to solve the problem or answer the question is not given	16	"State" p 7 "List" p 399 "Determine" p 477 "Estimate" pp 25, 145 "Calculate" pp 228, 599 "Write the equation" p 572
Instances where alternate representations are given or expected as a response	0	
Instances where a unique question is asked or a unique response is expected	3	"Write in words the meaning of ..." p 477 "Describe all errors which have been made" p 530

Assignments

I performed a similar analysis with the assignment pages that accompanied the lessons. Of the 33 pages analyzed, 18 contained what were designated as assignment questions. According to the documentation accompanying *Foundations*, "the assignments are intended to be done by the students individually, in pairs, or in small groups" (Appleby and Ranieri 2010, 1). There is no mention of projects, extended assignments or investigations that students are expected to complete on their own.

The results of my analysis of the 18 assignment pages with respect to the categories of questions asked are shown in Table 2 below.

The majority of the assignments in *Foundations* consist of question styles that either give the students the method to use or do not give a method, but ask students to calculate or determine. Many of the assignment questions were the straightforward, do-the-question-the-way-you-were-just-taught type of question. There were only two instances, both on the same page, that asked students to explain their thinking. The multiple choice and numeric-response questions were also basic complete-and-get-the-answer style. There was one multiple-choice question that required students to match an item with its corresponding value.

I appreciated the two questions that had a unique question style. One of the questions, on page 474, asked the students to explain and correct two errors in a given statement. This question would challenge students more than simply determining answers to similar questions would. The second question was

Table 2

Category	Number of Instances	Examples
Instances where students/teachers are asked to explain, describe or state a rule	4	"Describe" pp 421, 508 "Write a rule" p 540 p 637—After having students complete one question in two different ways: "Which method do you prefer?"
Instances where the method to be used to solve the problem or answer the question is given	14	"Solve ... by ..." p 637 "Use ... to ..." pp 421, 358 "Determine ... using ..." p 540 "Without using technology, graph ..." p 617 "Estimate the value mentally" then use the calculator to verify—p 30
Instances where the method to be used to solve the problem or answer the question is not given	53[3]	"Simplify" p 101 "Sketch" pp 453, 498 "Write ... as ..." p 101 "Determine" pp. 498, 574 "Write the equation" p. 574 "Calculate" p. 230, 498, 508 "Verify the solution." p. 617 "Arrange the following" p. 270 pp. 150, 226, 255, 421 contained multiple-choice and/or numeric-response questions
Instances where alternative representations are given or expected as a response	1	"Provide two sets of answers to the problem" p 474
Instances where a unique question is asked or a unique response is expected	3	"Explain two errors" p 474 "Explain clearly how to use the graph to determine ..." p 474 "Match each item in List 1 ... with the equivalent item in List 2 ... Each item in list 2 may be used once, more than once, or not at all." p 240

the matching question on page 240. This question was also challenging in that one set of characteristics to be matched contained more choices than the other set, so not all of the items were to be used. The question also stated that "each item in List 2 may be used once, more than once, or not at all" (p 240). Including this statement makes the question even more challenging, because students would have to consider each option several times before matching it to the appropriate choice.

Practice Tests

As the practice tests represented a small portion of my overall sample (only 3 of 33 pages), there was only a limited variety of questioning for analysis. According to the documentation accompanying *Foundations*, "the last lesson in each unit is a practice test which the students can complete at home or in class if time allows" (Appleby and Ranieri 2010, 1). The questions that make up the majority of each practice test are multiple choice and numeric response that ask for an answer to be chosen or given. On each practice test there is one written-response question that consists of multiple parts.

The results of my analysis of the three practice test pages with respect to the categories of questions asked are shown in Table 3 below.

In the questions on these pages, there was no expectation of different solution methods or strategies, though the students could use whatever strategy they chose to answer the multiple-choice or numeric-response questions. The sample contained one written-response question from the practice tests, which asked the students to explain why a particular card in a card game was valued at a specific value. There was no evidence that alternative strategies to complete the questions were valued or expected.

Conclusion

My analysis of the *Foundations of Mathematics and Pre-Calculus Grade 10 Workbook (for Math 10 Combined)* (Appleby and Ranieri 2010) answered my query whether the workbook is reflective of the intent of the program of studies. I did not see strong evidence that this resource fully supports the philosophy of the Alberta Mathematics 10–12 program of studies (2008). The most common question styles in the analyzed pages asked the teacher or the student to provide a solution either by a designated method or by a method that was assumed to have been taught in the lesson. There are few instances of students being asked to communicate their mathematical understanding or to express why. I found very few questions that challenged students to think about what they were being asked to do or to question the validity of the processes and procedures they were being asked to use. My conclusion is that the use of the *Foundations of Mathematics and Pre-Calculus Grade 10 Workbook (for Math 10 Combined)* (2010) for instruction would not support the philosophy of mathematics

Table 3

Category	Number of Instances	Examples
Instances where students/teachers are asked to explain, describe or state a rule	0	
Instances where the method to be used to solve the problem or answer the question is given	1	"Susan solves ... by ..." p 660
Instances where the method to be used to solve the problem or answer the question is not given	8	pp 58, 610, and 660 contained multiple-choice and/or numeric-response questions
Instances where alternative representations are given or expected as a response	0	
Instances where a unique question is asked or a unique response is expected	0	

education as presented in the Alberta mathematics Grades 10–12 program of studies.

Notes

1. For ease of reading, I will use the word *Foundations* to refer to *Foundations of Mathematics and Pre-Calculus Grade 10 Workbook (for Math 10 Combined)* (2010).

2. This is not meant to be an exhaustive list of the types of questions in the assignments; it is just a sampling of the assignment questions students would encounter.

3. Many of the questions included in these pages contained multiple parts that had the same instruction and thus were not counted separately.

References

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