3-2012

Undergraduate students' self-reported use of mathematics textbooks

Aaron Weinberg

Emilie Wiesner

Bret Benesh
College of Saint Benedict/Saint John's University, bbenesh@csbsju.edu

Timothy Boester

Recommended Citation
Weinberg A, Wiesner E, Benesh B, Boester T. 2012. Undergraduate students' self-reported use of mathematics textbooks. *PRIMUS: Problems, Resources, and Issues in Mathematics Undergraduate Studies* 22(2): 152-175.

UNDERGRADUATE STUDENTS' SELF-REPORTED USE OF MATHEMATICS TEXTBOOKS

Aaron Weinberg
Department of Mathematics
Ithaca College
Ithaca, NY 14850, USA
aweinberg@ithaca.edu

Emilie Wiesner
Department of Mathematics
Ithaca College
Ithaca, NY 14850, USA
ewiesner@ithaca.edu

Bret Benesh
Department of Mathematics
College of St. Benedict and St. John's University
St. Joseph, MN 56374, USA
bbenesh@csbsju.edu

Timothy Boester
Department of Mathematics and Statistics
Wright State University
Dayton, OH 45435, USA
timothy.boester@wright.edu

UNDERGRADUATE STUDENTS' SELF-REPORTED USE OF MATHEMATICS TEXTBOOKS

Abstract: Textbooks play an important role in undergraduate mathematics courses and have the potential to impact student learning. However, there have been few studies that describe students' textbook use in detail. In this study, 1156 undergraduate students in introductory mathematics classes were surveyed to describe how they used their textbook. The results indicate that students tend to use examples instead of the expository text to build their mathematical understanding, which instructors may view as problematic. This way of using the textbook may be the result of the textbook structure itself as well as students' beliefs about reading and the nature of mathematics. Although many instructors may not clearly convey how they want their students to use the textbook, students do report using it more productively when they believe they are asked to do so. This suggests that instructors should carefully choose text materials to promote mathematical reasoning and actively encourage their students to read the text in a way that supports the development of this reasoning.

Keywords: Textbooks, Content-Area Reading, Undergraduate Mathematics

1 INTRODUCTION

Mathematics textbooks serve many purposes, but the most important is to foster student learning. Moreover, the nature of textbooks—filled with explanations, examples, and applications—suggests the expectation that students read the textbook. Although the content, from a topical viewpoint, may be available to students through class lectures, some educators have argued that reading mathematics provides students with unique learning opportunities. Cowen [14] contends that learning to read mathematics should be a fundamental goal of undergraduate mathematics courses, as it provides a path for understanding mathematical theory as opposed to only mastering procedural skills. Shepherd argues that reading mathematics creates "independent learners" [42, p. 125]. This highlights the importance of undertaking research on the nature of textbooks and the ways that students interact with textbooks. The goal of this study is to examine how students in introductory mathematics classes report using their textbook. Additionally, the study investigates the interactions among students' values, their perception of their instructor's implementation of the curriculum, and their self-reported textbook use.

2 PREVIOUS RESULTS

There is little research on the ways that students use their textbooks, particularly at the undergraduate level. This may be due to the prevalence of research at the K-12 level and the corresponding focus on curriculum over textbook (e.g. [2], [39]). Much of the existing research describes the linguistic or structural features of textbooks themselves (e.g. [7], [19], [40]) and how some of these features may affect student learning (e.g. [34]).

There is one study at the undergraduate level that focuses on mathematics students' use of textbooks: Lithner [25] analyzed the strategies used by college students as they worked through a set of textbook calculus exercises selected by the researcher. Lithner described the prevalence of an "Identification of Similarities" strategy in which the student focused on identifying superficial similarities between the exercise and earlier portions of the textbook. This finding is consistent with research in other disciplines. For example, Richardson [38] described how economics students sought to duplicate the information in their textbook, which they viewed as an immutable source of authoritative, legitimated knowledge. Similarly, Wandersee [49] found that teacher-education students attempted to replicate or extract information from the textbook instead of constructing a personal understanding.

3 THEORETICAL BACKGROUND AND RESEARCH QUESTIONS

A striking feature of introductory undergraduate mathematics textbooks is the uniformity of their organizational structure. This suggests uniformity in the ways that textbooks are intended to be used. Moreover, authors often make explicit their intentions that students read the textbook in particular ways. For example, Hughes-Hallet, McCallum, et al. give the following advice to students:

> Your success in using this book will depend on your reading, questioning, and thinking hard about the ideas presented... you should plan on reading the text in detail, not just the worked examples.... You can't just look at a homework problem and search for a similar-looking 'worked out' example. [21, p. x]

This passage highlights a tension between the intentions of the author/textbook and the perceived tendencies of students. Namely, the authors require that the readers read in a particular way but believe that readers are likely to not do so. Eco's notion of a closed text [17] provides a useful theoretical perspective on this tension and on the role that the textbook plays in the student-textbook relationship. Eco defined a *closed text* as one that seeks to elicit a "precise response" from a reader at each step along a preconceived path [17, p. 8]. Love and Pimm have posited that all mathematics textbooks are essentially closed and that typical mathematics textbook components, such as explanations, examples, and exercises, act as "devices used to organize the reader's work within the text" [28, p. 386], a position that is supported by Rezat [37]. This position has been echoed by Otte, who noted: "The texts aim at a precise fixation of every single step of the student" [35, p. 25]. Weinberg and Wiesner [50] have given a more detailed description of the closed nature of mathematics textbooks.

A closed text is left open to inappropriate interpretations by readers who do not follow the precise path laid out for them. In the case of mathematics textbooks, "the flow of the lessons is changed and the lessons in the textbooks might not be used as intended by the authors" [37, p. 486]. If "students are often impatient with the exposition and skip to the 'essential' results," they will struggle to use the text to understand mathematics [28, p. 387]. Lithner's description of "Identification of Similarities" provides an example: "[this strategy] often misleads [students], takes time, and makes it hard to distinguish useful information from useless information" [25, p. 52].

This study focuses on students enrolled in introductory undergraduate mathematics classes (college algebra, discrete mathematics, calculus, introductory statistics, and mathematics content courses for pre-service elementary teachers) because these comprise the majority of courses that are taught in mathematics departments. The structure of the (closed) mathematics textbooks commonly used in these courses suggests an intention that students interact with the textbook contents in a precise way, thereby eliciting particular responses and actions. Thus, one approach to understanding the ways in which mathematics students use their textbook is to investigate the extent to which students are indeed using the specific components of their textbook at the intended times and for the intended purposes. This paper attempts to answer three broad questions about students' behavior and values as well as the role of the instructor:

1. To what extent do the ways students use textbooks follow the carefully laid-out paths that (closed) textbooks prescribe? Specifically, what text components do students use? When do students look at each component? What are their reasons for doing so?
2. If a student values certain characteristics of a textbook, is he or she more likely to use the book in a specific way?
3. In what ways does the instructor's implementation of the curriculum affect the student's textbook use?

4 FRAMEWORK

In order to address these research questions, a framework was developed to describe students' textbook use in terms of the textbooks' structural components and the factors affecting their textbook use. The framework has three principal elements:

1. a description of the structural components of textbooks;
2. the purposes and situative conditions under which students use their textbooks; and
3. other potential influences on students' textbook use.

4.1 Textbook components

The following description of structural components was generated by surveying the textbooks used by the students in the study. A subsequent survey of other widely-used textbooks[1] was conducted to verify that this structure was representative of introductory undergraduate mathematics textbooks.

- The *chapter introduction* is located at the beginning of each chapter or unit. It describes the content that will follow, possibly giving motivation for including the content and drawing connections with other topics in the book.
- The *chapter text* contains the exposition and content kernels—the definitions, theorems, procedures, formulas, and descriptions of how each of these is related to the others and the topic of the chapter or unit.
- The *examples* are frequently embedded in the chapter text or are placed immediately after the chapter text but before the homework problems.

[1]The list of textbooks included both the textbooks used by students in this study and textbooks that representatives from major publishing companies identified as popular. The list includes: [1, 4, 5, 6, 8, 9, 11, 12, 15, 16, 18, 20, 21, 22, 23, 27, 29, 30, 31, 32, 33, 43, 44, 45, 46, 47, 48].

- The *homework problems* are typically included after the chapter text and examples. These consist of problems that can be solved using the ideas and techniques described in the chapter text and are frequently similar to the examples.
- The *chapter summary* is a recapitulation of the content kernels included at the end of the chapter or unit. It is generally composed of a list of terms, phrases, or questions which a student could use as a basis for reviewing the chapter but which contains little or no new exposition in its own right.
- The *answers to exercises* (or solutions manual) is frequently included at the end of the textbook and consists of either short answers to a subset of the homework problems or a brief outline of how to complete these problems.

This list of components mirrors Rezat's [37] description of the structure of mathematics textbooks. He viewed this structure as a representation of an idealized thought process "characterized by apperception and generalization" [37, p. 485] through which the author envisions the learner progressing. Moreover, Rezat showed how the sequence of textbook components parallels specific learning stages in theories of instruction. For example, the theories begin with "a phase of motivation that has to precede the whole [instructional] process" [37, p. 485], which corresponds to the chapter introduction.

4.2 Purposes and situative conditions

If the textbook components are viewed as stages through which the reader must progress, then the context in which the reader uses each component is also important.

To address this, the authors generated a list of purposes for using the textbook and situative conditions during which students might use the textbook, based on their experience as instructors. We recruited nine undergraduate students to keep "textbook-use journals" and an additional eighteen students to participate in structured interviews (the journal template can be found in Appendix A and the interview protocol can be found in Appendix B). These students were enrolled in a wide range of mathematics courses (including pre-calculus, first- and second-semester calculus, introductory statistics, and several upper-level mathematics courses) and participated voluntarily. The journals and interviews corroborated and sometimes refined the initial list of contexts.

The following list of purposes represents students' potential reasons for using each part of the text.

1. Read for better understanding.
2. Make sense of definitions or theorems.
3. Look up definitions or theorems.
4. Rephrase/summarize text (for notes, homework, etc.).
5. Read the homework problems to see what ideas come up most frequently.
6. Use the answers to exercises to check homework.
7. Use extra problems and answers to exercises to check understanding of problems that weren't assigned.
8. Read or copy homework problems to complete homework assignments.
9. Look up answers without solving the problems.

The following list describes the conditions in which students primarily use their textbook outside of class:

1. preparing for class;
2. doing homework (or other graded assignments); and
3. studying for exams

4.3 Other potential influences on students' textbook use

Schoenfeld [41] notes that a student's beliefs about mathematics affect how they engage in mathematical activity. Thus, while the design of a textbook may suggest particular ways of using the text, students' beliefs—reflected in the qualities they value in a textbook—may also affect their textbook use. Based on Schoenfeld's description and Lloyd and

Behm's [26] list of values, this framework includes five primary beliefs students have about their textbook.

1. A textbook should explain the "big ideas" of the course.
2. A textbook should explain the "underlying concepts" of problems.
3. A textbook should give examples to explain the material.
4. A textbook should give examples that can be used to complete homework.
5. A textbook should highlight important equations and definitions.

Although previous studies have found that teachers are important in shaping student-textbook interactions at the K-12 level, there has not been research on the instructor's influence at the undergraduate level. Moreover, at the undergraduate level the student's relationship with the textbook exists primarily outside of class. This suggests that attention be paid to the influence that the teacher may have on the student-textbook relationship through explicit assignments as well as course structuring. This framework includes two categories designed to determine whether the instructor influences the way students use textbooks through explicit assignments and course structuring.

1. The first category includes the ways that students perceive they are asked to use the textbook by their instructor. The instructor might ask students to read the chapter text, do homework problems, look up definitions or theorems, or look at examples.
2. The second category includes the degree to which the textbook is perceived to be aligned with the course.

5 SUBJECTS AND METHODS

A survey was conducted in introductory mathematics classes at three institutions in the United States: a large southern public university ("School A"), a large northeastern private university ("School B"), and a medium-sized northeastern private college ("School C"); all courses selected for the survey had a required textbook. The researchers asked all instructors of introductory mathematics classes at each institution to administer the survey, and instructors did so voluntarily. A total of 1156 students were surveyed; the classes surveyed and the response rates are shown in Table 1.

Table 1. Number of Sections and Students Surveyed by Institution

Course	School	Sections	Students
Algebra	A	13 (30)	240 (1439)
	B		
	C	0 (1)	0 (23)
Calculus	A	15 (38)	344 (1276)
	B	7 (18)	75 (355)
	C	5 (9)	86 (213)
Discrete	A	2 (7)	63 (226)
Mathematics	B		
	C	2 (4)	54 (132)
Statistics	A		
	B		
	C	7 (12)	157 (327)
Mathematics for	A	6 (9)	137 (230)
Elementary School	B		
Teachers	C		

Note: Numbers in parentheses represent the number of sections/students that were taught that semester (including those surveyed). Empty cells indicate that the course was not taught in the mathematics department at the corresponding school.

The classes surveyed were primarily intended for students pursuing a four-year B.A. or B.S. degree who were not mathematics majors; the students enrolled (including those in teacher-education classes) were predominantly first- and second-year college undergraduates. All of the classes were taught in small sections of up to 30 students. The survey was administered during a normal class session late in the semester.

The anonymous written survey, which can be found in Appendix C, consisted of ten questions. In the survey, students reported on what parts of the textbook they used, when they used the textbook, and for what purpose. There were also questions addressing how the textbook was incorporated into the class and what characteristics students valued in a mathematics textbook.

6 RESULTS

This section presents a summary of the survey data; interpretations of this summary appear in the "Analysis and Discussion" section.

The results were tested for statistical significance using either a chi-square test, a McNemar test, or a Cochran's Q-test. As used in this study, the chi-square test determines whether the percentages in two independent samples are close enough to suggest that the two underlying populations have corresponding percentages that are equal to each other. The McNemar test gives similar information when dealing with matched pairs (e.g. measuring the same group of students twice and comparing the percentages). The Cochran's Q-test is similar to the McNemar test but compares three or more percentages. All of the tests used a non-directional null hypothesis.

At the beginning of the survey, students were asked to indicate if they had their own textbook, shared or borrowed a copy, used instructor's notes, or did not use a textbook. Virtually all (92%) students in this sample reported that they owned their own copy of the textbook, while almost no students used their instructor's notes or didn't use a textbook (1% for each).

6.1 Students' Textbook Use

6.1.1 Chapter overviews and expository text

There were significant differences in students' reported use of various textbook components (see Table 2).[2] In particular, students reported using the chapter introduction and chapter summary significantly less

[2] A Cochran's Q-test was conducted ($Q(5) = 4181.5$, $p < .001$).

than the other components.[3] In addition, a large percent of students also reported not reading the chapter text. For each component, there were some course-school groups with higher percentages. For example, 59% of statistics students at school C read the chapter summary and 85% of calculus students at school A looked at the homework solutions. Although some of these individual differences are significant, there was no course-school group that consistently reported using the textbook components at higher rates than other groups.

Table 2: Percentage of students who reported using each component of their textbook.

Component	Percentage of Students
Chapter Introduction	24.7
Chapter Test	63.3
Examples	89.4
Chapter Summary	29.2
Homework Problems	79.9
Homework Solutions	71.8

Of those students that did use the chapter text, most reported doing so while completing homework or studying for exams, and relatively few reported using it to prepare for class (see Table 3). As above, there was some variation among the classes and schools (e.g. 70% of the algebra students at school A and 97% of the calculus students at school B reported using the textbook to complete homework), but there was

[3] Pairwise McNemar tests were conducted to compare the percent of students who reported using each component. The tests compared the percent of students who reported using the introduction vs. using the chapter text ($p < .001$), introduction vs. examples ($p < .001$), introduction vs. summary ($p = .00889$), introduction vs. problems ($p < .001$), introduction vs. solutions ($p < .0001$), text vs. examples ($p < .001$), text vs. summary ($p < .001$), text vs. problems ($p < .001$), text vs. solutions ($p < .001$), examples vs. summary ($p < .001$), examples vs. problems ($p < .001$), examples vs. solutions ($p < .001$), summary vs. problems ($p < .001$), summary vs. solutions ($p < .001$), and problems vs. solutions ($p < .001$). These comparisons are all significant using Bonferroni-adjusted alpha-levels of .00333 except for the introduction-summary comparison.

no course-school group that had a consistently higher or lower reported rate.

Table 3. Students' use of the chapter text.

Situative Condition	Preparing for Class	Completing Homework	Studying for Exams	Other Times
Percentage of Students	18.0	85.2	83.6	11.9

Note: Percentages are taken from among those students who reported using the chapter text (n=742).

Among students who read the chapter text, approximately 90% "read for better understanding," "look[ed] up definitions or theorems," or read to "make sense of definitions or theorems" (see Table 4). There was considerable variation in the percentage of students who rephrased the text (e.g. 81% of pre-service teachers used the textbook for this purpose, while only 56% of calculus students at school B did this) as well as the percentage who used it for other reasons (e.g. 13% of discrete students at school C and 29% of algebra students at school A). As above, there was no course-school group that had a consistently higher or lower reported rate.

Table 4. Students' reasons for reading the chapter text.

Reason for Reading	Percentage of Students
Read for Understanding	92.8
Look Up Definitions	89.3
Make Sense of Definitions	89.3
Rephrase or Summarize	68.0
Other Reasons	23.5

Note: The percentages given are from those students who reported using the chapter text (n=742).

6.1.2 Examples

Students reported using the worked examples more than any other part of the textbook (see Table 2 and footnote 3). They reported using examples primarily while completing homework and studying for exams (see Table 5). As with the other results, there is some notable variation among classes and schools (e.g. 82% of algebra students at school A reported using examples while studying for exams while only 70% of calculus students at school C did so), but there was no course-school group that had a consistently higher or lower reported rate.

Table 5. Students' use of worked examples.

Situative Condition	Preparing for Class	Completing Homework	Studying for Exams	Other Times
Percentage of Students	14.5	84.7	77.2	7.9

Note: The percentages are from those students who reported using the worked examples ($n = 1036$).

There are significant differences among students' reported reasons for using the examples.[4] According to students' reports, the most common reason for looking at examples was to "read for better understanding" (see Table 6)[5]. This was reflected by what students valued most highly; there were significant differences among the relative value students placed on various aspects of the text.[6] In particular, students were more likely to value textbooks that give "lots of examples to help you understand the material" and "lots of examples to use on the homework" than textbooks that explain "the big ideas of the course" and "the under-

[4] A Cochran's Q-test was conducted ($Q(3) = 1466.364$, $p < .001$).

[5] Pairwise McNemar tests were conducted to compare the percentages of students who reported reading for understanding vs. looking up definitions ($p < .001$), understanding vs. rephrase ($p < .001$), understanding vs. other ($p < .001$), definitions vs. rephrase ($p < .001$), definitions vs. other ($p < .001$), and rephrase vs. other ($p < .001$). Using Bonferroni-adjusted alpha-levels of .0083, all of these comparisons are significant.

[6] A Cochran's Q test was conducted ($Q(4) = 105.385$, $p < .001$).

lying concepts of problems you are working on" (see Table 7)[7]. Students tended to value highly textbooks that "highlight important definitions and equations" more than most other aspects of their textbooks (see Table 7).

Table 6. Students' reasons for using the worked examples.

Reason for Reading	Read for Understanding	Make Sense of Definitions	Rephrase or Summarize	Other Reasons
Percentage of Students	94.7	87.0	71.5	24.4

Note: The percentages given are from those students who reported using the worked examples ($n = 1036$).

Table 7. The aspects of textbooks that students value highly.

Aspect	Percentage of Students
Explains the big ideas of the course	66.4
Explains underlying concepts of problems	68.0
Gives lots of examples to help you understand material	77.5
Gives lots of examples to use on the homework	75.0
Highlights important definitions and equations	80.3

Note: Responses were on a scale of 1 to 5 with 1 low and 5 high. Responses of 4 or 5 were coded as valuing the aspect "highly."

[7]Pairwise McNemar tests were conducted for ideas vs. concepts ($p = .739$), ideas vs. understand ($p < .001$), ideas vs. homework ($p < .001$), ideas vs. highlights ($p < .001$), concepts vs. understand ($p < .001$), concepts vs. homework ($p < .001$), concepts vs. highlights ($p < .001$), understand vs. homework ($p = .0129$), understand vs. highlights ($p = .00956$), and homework vs. highlights ($p < .001$). Using Bonferroni-adjusted alpha-levels of .005, all but three of these comparisons are significant.

6.1.3 Homework problems and the solutions manual

A large percentage of students reported using both the homework exercises and the exercise answers or solutions manual (see Table homeworkuse). Students were most likely to report using the homework exercises to complete homework (see Table 8)[8] although there was considerable variation between the course-school groups (e.g. 94% of pre-service teachers at school A reported doing this while only 54% of algebra students at school A did so). Similarly, students were most likely to report using the exercise solutions to check the correctness of their homework (see Table 9).[9]

Table 8. Students' use of homework exercises.

Use of homework exercises	Read/copy to complete problems	Read to see what ideas come up frequently	Other reasons
Percentage of Students	81.0	63.6	21.4

Note: The percentages given are from all students surveyed.

Some instructors may believe that students simply look up the answers to assigned homework problems and turn them in. Roughly a third (37%) of all students who looked at the solutions manual (which corresponds to 28% of all students) reported at least "sometimes" copying homework solutions before attempting to solve the problem on their own. Few students reported using answers in this way "often" or "always" (see Table 10), although this varied among the course-school groups (e.g. 2% of calculus students at school C reported using the answers "often" or

[8]Pairwise McNemar tests were conducted for problems vs. ideas ($p < .001$), problems vs. other ($p < .001$), and ideas vs. other ($p < .001$). Using Bonferroni-adjusted alpha-levels of .0167, all of these comparisons are significant.

[9]Pairwise McNemar tests were conducted for homework vs. understanding ($p < .001$), homework vs. answers ($p < .001$), homework vs. other ($p < .001$), understanding vs. answers ($p < .001$), understanding vs. other ($p < .001$), and answers vs. other ($p = .002$). Using Bonferroni-adjusted alpha-levels of .0083, all of these comparisons are significant.

Table 9. Students' use of exercise answers/solutions manual.

Use of Homework Solutions	Percentage of Students
Check homework	58.7
Check understanding of unassigned problems	28.3
Look up answers without solving problems	8.1
Other reasons	5.2

Note: The percentages given represent those students who reported using the exercise answers or solutions manual for this reason "often" or "always," among all students taking the survey.

"always" but 18% of pre-service teachers at school A reported doing this).

Table 10: How often students looked up answers without attempting problems.

Frequency	Rarely or Never	Sometimes	Often or Always
Percentage of Students	62.2	26.2	11.0

Note: The percentages are from those students who reported using the exercise answers or solutions manual.

6.2 Potential Influences on Students' Textbook Use

6.2.1 Class alignment with the textbook

Students were asked to indicate whether or not their class closely followed the textbook or covered different material than the textbook. This distinction did not have a significant impact on the percentage of students who reported reading the chapter text at any time[10] or the percent-

[10] A χ^2-test was conducted for reading the chapter text at any time vs. the class closely follows the text ($\chi^2(1, n = 1156) = .03$, $p = .862$).

age of students who read any part of the textbook for understanding.[11]

6.2.2 Perceived instructor requests.

If students think they are asked to use a textbook in any way they tend to report using it in multiple ways. When students thought their instructor asked them to read the chapter text frequently (i.e. daily or weekly), they were generally more likely to report using the text for various purposes than if they thought their instructor asked them to look at the chapter text infrequently (i.e. monthly or never) (for examples, see Table 11).

Table 11: Association between textbook use and perceived requests to read.

	How often students perceive they are asked to read the chapter text		
Action	Daily/Weekly ($n = 591$)	Monthly/Never ($n = 517$)	Significance
Read the Chapter Text	71.1%	55.7%	$\chi^2(1, n = 1108) = 28.9$, $p < .001$
Read the Chapter Introduction	32.7	16.6	$\chi^2(1, n = 1108) = 37.6$, $p < .001$
Read Examples	93.2	85.9	$\chi^2(1, n = 1108) = 16.3$, $p < .001$
Read for Understanding	93.6	84.7	$\chi^2(1, n = 1108) = 22.9$, $p < .001$
Read when Preparing for Class	23.0	12.8	$\chi^2(1, n = 1108) = 19.4$, $p < .001$

Note: The percentages given represent the percent of students in each frequency category that reported using the stated textbook component.

[11] A χ^2-test was conducted for reading for understanding vs. the class closely follows the text ($\chi^2(1, n = 1156) = .074$, $p = .786$).

Although students' textbook use appears to be connected to their perceptions of instructor expectations, there was considerable variation within each class in how students believed they were asked to use the textbook. Students were asked to report how frequently they think their instructor asks them to read the text, look up examples, look up definitions, or do homework; student responses were categorized as either frequently (daily or weekly) or infrequently (monthly or never). For each class, the percentage of students who reported that they were "frequently" asked to use the textbook in a particular way was computed. The results, shown in Figure 1, display the distribution of these percentages. Within many classes, almost all students agreed that they were frequently asked to complete homework. Although the majority of students in most classes agreed that the instructor frequently asked them to read examples from the textbook, there were large percentages of students who did not agree with the majority. In addition, students were most likely to disagree about how frequently the instructor asked them to read the chapter text, as evidenced by the high frequency of classes with agreement near 50%.

6.3 Student values

In addition to the perceived expectations of the instructor, a student's own values influence how he or she reports using the textbook. Students who valued conceptual understanding highly reported using more parts of the textbook than students who valued worked examples. Students who valued a textbook that "explain[s] the big ideas of the course" (i.e. they rated this attribute a 4 or 5 on a scale of 1 to 5) were generally more likely to report reading the chapter text at any time than students who didn't value this attribute. Similarly, students who shared this value were significantly more likely to "read for understanding" (see Table 12). The findings were similar for students who valued a textbook that "explain[s] the underlying concepts of problems."

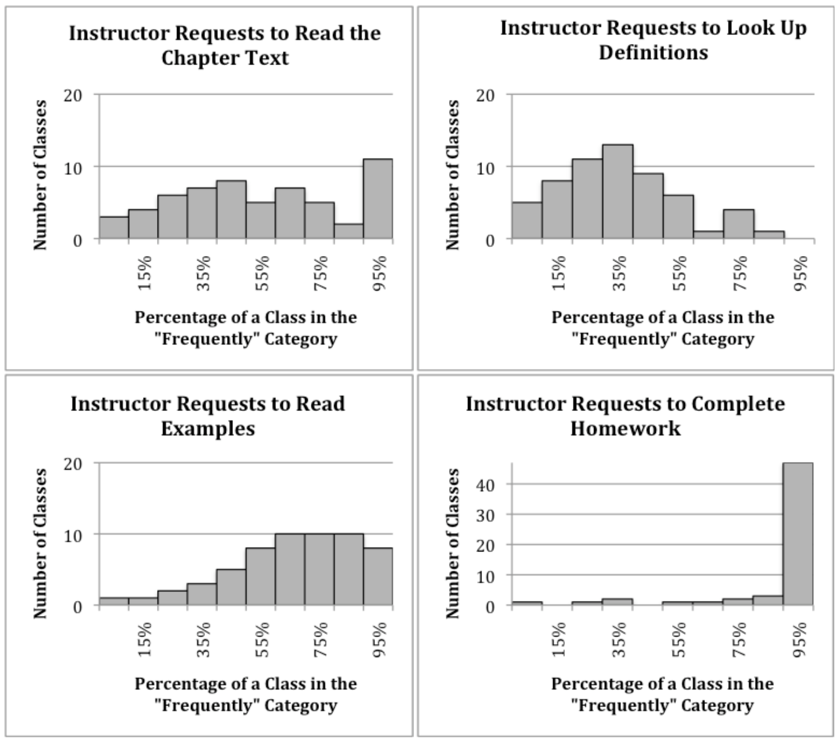

Figure 1: Students' reports, by class, on the frequency of instructors' requests. Students' reports of their instructor's requests to use the textbook were grouped as frequently (daily or weekly) or infrequently (monthly or never).

Table 12. Student values and textbook use.

Action	How students value a textbook that "explains the big ideas" Highly (n=768)	Not Highly (n=388)	Significance
Read the Chapter Text	69.0%	52.1%	$\chi^2(1, n = 1156) = 31.9$, $p < .001$
Read for Understanding	93.2	80.9	$\chi^2(1, n = 1156) = 40.2$, $p < .001$

7 ANALYSIS AND DISCUSSION

The text components, along with other features of the textbook, seek to control the reader's progress through the text. However, many students report using the text in ways that are not consistent with the intended goals that are conveyed by the text structure. Students neglect to read the chapter introduction and—to a lesser extent—the chapter text. These are the portions of the text in which the author attempts to develop a deeper understanding of the mathematical concepts. In addition, students primarily report using the text when doing homework problems or studying for exams, and not as an ongoing resource for understanding material from class sessions.

Instead of following the path outlined by the (closed) text, students gravitate toward worked examples and view them as a means to increase their understanding. Many students also report reading homework problems that were not assigned (to "see what ideas come up most frequently") and their solutions (to "check understanding"). This indicates that students believe recognizing problem-types and looking at worked-out solutions—or even numerical answers—is a valuable tool in their success in class. This is consistent with students' stated preferences for textbooks that contain useful examples and separate the content kernels (such as definitions and theorems) from the exposition. These results suggest that students are looking for algorithms and shortcuts, which mirrors Lithner's [25] description of his subjects relying on an "Identification of Similarities" strategy to solve mathematics problems.

The data also reveal an apparent conflict between students' goals and actions. Students claim that they read the textbook to gain understanding of the mathematics but then neglect to use the text in the ways that are compatible with the author's attempts to develop that understanding. This apparent conflict may be a result of students' beliefs about mathematics. As Schoenfeld [41] has described, many students view mathematics as a collection of techniques to be memorized and applied, a subject in which there is one correct answer and one way to obtain the answer. From this perspective, "understanding" mathematics may be equivalent to correctly following procedures.

The actions and values described by the students in this study may undermine their attempts to use the textbook to learn mathematics. As Love and Pimm note, when the text so clearly signals the important results of the textbook by extracting the kernels from the exposition and using examples as a model for homework problems, it is natural that students become "impatient with the exposition" and "skip to the 'essential' results" [28, p. 387]. This is precisely what many students report doing in this study: they are less likely to read the introduction and chapter text than the other components, and these are generally the components that the author intends to help the students generate meaning. In doing so, students are less likely to use the lessons "as intended by the authors" [37, p. 486] and, thus, to miss the "precise response" [17, p. 8] planned by the author. Weinberg and Wiesner [50] have argued that skipping the exposition may make it difficult for students to interpret other elements of the text. In addition, students place a relatively low value on textbooks that help them wrestle with the "big ideas" or help them investigate the "underlying concepts of problems." Instead, they report using the text primarily for homework and exams and focus on using examples over generating meaning from the exposition.

Although this study investigated the teacher component of the teacher-student-textbook relationship in only a limited way, our results show that instructors may play a role in students' textbook use. When students perceive that they are asked to use their textbook, they report that they are more likely to do so. At the same time, there is a lack of agreement among students about what their instructors expect them to do with their textbooks. Although the conclusions that can be drawn from these results are limited, they suggest that instructors may be able to increase students' use of their textbooks by asking their students to use their textbooks in multiple ways and then clearly communicating their expectations.

Instructors are in a position to encourage their students to use textbooks more productively. The ways students use a textbook may be driven by the methods their instructor uses to assess their mathematical understanding, which often takes the form of homework exercises or exams. Many textbooks include homework problems that are similar to the examples in the chapter text; when instructors assign such problems, they make strategies such as "Identification of Similarities" more effective for completing assessments. An instructor could help his or her students to use the textbook to investigate "big ideas" by choosing homework problems that require a deeper understanding than using the same method as a previous example (what Lithner [25] describes as "Plausible Reasoning") and by choosing exam questions that encourage multiple interpretations and solution strategies.

Although it is important for instructors to clearly communicate their expectations, this study did not reveal any consequences of the way that the class is aligned with the textbook. A perception that the class closely adheres to the textbook—both in content and order—does not significantly impact the ways students report using their textbook.

7.1 Open Questions

The design of this survey has several limitations that lead to important open questions. The self-reporting design means there is no way of assessing the validity of students' descriptions of their textbook use. In addition, the response categories (such as "while studying for exams") were researcher-imposed. Although textbook-use diaries were used to corroborate the categories that were used on the survey, it would be helpful to give space for open response on the survey to investigate other response categories students would create. Related to this, the results of this survey may be clouded by students' interpretations of the terminology used on the survey, such as "read for understanding" or "rephrase."

The survey also does not describe how the textbook is incorporated into the class from the instructor's perspective. This could be addressed by supplementing the students' assessment with a form for instructors to describe how they incorporate the textbook into the course. In addition, it would be informative to gather data that describe the tools instructors use to assess their students; these assessment instruments may affect students' goals in their mathematics class and, consequently, the ways they use their textbook.

Additionally, it would be useful to consider students' perceptions of the effectiveness of class lectures and discussions. If students feel that their instructor creates opportunities to make sense of the material in class, they may view the examples as the only useful component of the textbook. Conversely, students who do not feel that the class discussion and lecture is sufficient to help them understand the material may be more likely to turn to their textbook. To investigate this further, items that ask students to describe the ways their instructor creates learning opportunities in class would be a useful supplement to this survey.

8 CONCLUSIONS

In general, students seem to value textbooks that provide them with clear examples that are similar to problems on their homework and exams. While they believe they are using their textbooks to get a better understanding of their class material, they do not see developing an understanding of the "big ideas" as leading to success in mathematics. These patterns of student textbook use may reflect students' beliefs about mathematics, as well as the nature of mathematics textbooks themselves.

These results raise important questions about the role of textbooks in undergraduate mathematics classes. It is important for instructors and researchers to discuss the role of the textbook in the class, to help students learn the best ways to use (closed) textbooks, and to find new materials that support the ways students tend to use their textbooks. The instructor can potentially play an important role in helping students use their textbooks and, in doing so, help their students develop a deeper understanding of mathematical processes and content.

REFERENCES

[1] Aufmann, R. N., V. C. Barker, and R. D. Nation, 2008: *College Algebra*. 6th ed. New York: Houghton Mifflin, 832 pp.

[2] Ball, D. L., and D. K. Cohen, 1996: Reform by the book: What is–or might be–the role of curriculum materials in teacher learning and instructional reform? *Educational Researcher*, 25 (9), 6–14.

[3] Ball, D. L., and S. Feiman-Nemser, 1988: Using textbooks and teachers' guides: A dilemma for beginning teachers and teacher educators. *Curriculum Inquiry*, 18 (4), 401–423.

[4] Bassarear, T., 2005: *Mathematics for Elementary School Teachers*. 3rd ed. Boston: Houghton Mifflin, 704 pp.

[5] Beckmann, S., 2008: *Mathematics for Elementary Teachers*. 2nd ed. New York: Pearson Education, 885 pp.

[6] Berresford, G., and A. Rockett, 2001: *Finite Mathematics*. Boston: Houghton Mifflin, 614 pp.

[7] Bierhoff, H., 1996: A comparison of primary school textbooks in Britain, Germany, and Switzerland. *Teaching Mathematics and its Applications*, 15 (4), 141–160.

[8] Billstein, R., S. Libeskind, and J. W. Lott, 2004: *A Problem Solving Approach to Mathematics for Elementary School Teachers*. 8th ed. Boston: Pearson Education, 912 pp.

[9] Blitzer, R., 2008: *Intermediate Algebra for College Students*. 5th ed. Upper Saddle River, NJ: Prentice Hall, 960 pp.

[10] Clump, M. A., H. Bauer, and C. Bradley, 2004: The extent to which psychology students read textbooks: A multiple class analysis of reading across the psychology curriculum. *Journal of Instructional Psychology*, 31 (3), 227–232.

[11] Cohen, D., 2005: *Precalculus*. 4th ed. St. Paul, MN: West, 1200 pp.

[12] COMAP, 2003: *For All Practical Purposes*. 6th ed. New York: W. H. Freeman, 853 pp.

[13] Conference Board of the Mathematical Sciences, cited 2008: The mathematical education of teachers. [Available online at `http://www.cbmsweb.org/MET_Document/index.htm` (Accessed July 14, 2010).]

[14] Cowen, C. C., 1991: Teaching and testing mathematics reading. *The American Mathematical Monthly*, 98 (1), 50–53.

[15] Crauder, B., B. Evans, and A. Noell, 2007: *Functions and Change*. 3rd ed. New York: Houghton Mifflin, 527 pp.

[16] DeVeaux, R. D., P. F. Velleman, and D. E. Bock, 2006: *Intro Stats*. 3rd ed. New York: Pearson Education, 768 pp.

[17] Eco, U., 1979: *The Role of the Reader: Explorations in the Semiotics of Texts*. Indiana University Press, 288 pp.

[18] Edwards, C. H., and D. E. Penney, 1997: *Calculus with Analytic Geometry: Early Transcendentals*. 5th ed. Upper Saddle River, NJ: Prentice Hall, 1028 pp.

[19] Herbel-Eisenmann, B., and D. Wagner, 2005: In the middle of nowhere: how a textbook can position the mathematics learner. *Proc. of the 29th Conf. IG PME*, Vol. 3, Melbourne, Australia, The International Group for the Psychology of Mathematics Education, 121–128.

[20] Hughes-Hallett, D. and Coauthors, 2006: *Applied Calculus*. 3rd ed. Hoboken, NJ: John Wiley and Sons, 528 pp.

[21] Hughes-Hallett, D. and Coauthors, 2006: *Calculus: Single Variable*. 4th ed. Hoboken, NJ: John Wiley and Sons, 718 pp.

[22] Larson, R., R. Hostetler, and B. Edwards, 2004: *Algebra and Trigonometry*. 4th ed. Pacific Grove, CA: Brooks Cole, 1072 pp.

[23] Larson, R., R. P. Hostetler, B. H. Edwards, and D. E. Heyd, 2002: *Calculus of a Single Variable*. 7th ed. Pacific Grove, CA: Brooks Cole, 857 pp.

[24] Li, Y., 2000: A comparison of problems that follow selected content presentations in American and Chinese mathematics textbooks. *Journal for Research in Mathematics Education*, 31 (2), 234–241.

[25] Lithner, J., 2003: Students' mathematical reasoning in university textbook exercises. *Educational Studies in Mathematics*, 52, 29–55.

[26] Lloyd, G. M., and S. Behm, 2002: *The impact of prospective elementary teachers' experiences with reform-oriented mathematics curriculum materials*. Paper presented at Annual Meeting of the American Educational Research Association, New Orleans, LA.

[27] Long, C., and D. DeTemple, 2006: *Mathematical Reasoning for Elementary Teachers*. 4th ed. Boston: Pearson, 1080 pp.

[28] Love, E., and D. Pimm, 1996: 'This is so': A text on texts. *International Handbook of Mathematics Education*, A. Bishops, K. Clements, C. Keitel, J. Kilpatrick, and C. Laborde, Trans., Kluwer Academic Publishing, 371–409.

[29] McClave, J., G. Benson, and T. Sincich, 2005: *Statistics for Business and Economics*. 9th ed. Upper Saddle River, NJ: Prentice Hall, 1216 pp .

[30] Moore, D., and G. McCabe, 2000: *Introduction to the Practice of Statistics*. 4th ed. W. H. Freeman, 828 pp.

[31] Moore, D. S., G. P. McCabe, W. M. Duckworth, and S. L. Sclove, 2000: *The Practice of Business Statistics*. New York: W. H. Freeman, 859 pp.

[32] Musser, G. L., W. F. Burger, and B. E. Peterson, 2008: *Mathematics for Elementary Teachers*. 7th ed. Hoboken, NJ: Wiley, 908 pp.

[33] Ostebee, A., and P. Zorn, 2002: *Calculus from Graphical, Numerical, and Symbolic Points of View*. 2nd ed. New York: Houghton Mifflin, 605 pp.

[34] Osterholm, M., 2006: Characterizing reading comprehension of mathematical texts. *Educational Studies in Mathematics*, 63 (3), 325–346.

[35] Otte, M., 1983: Textual strategies. *For the Learning of Mathematics*, 3 (3), 15–28.

[36] Reys, B. J., R. E. Reys, and O. Chavez, 2004: Why mathematics textbooks matter. *Educational Leadership*, (5), 61–66.

[37] Rezat, S., 2006: The structures of German mathematics textbooks. *Zentralblatt für Didaktik der Mathematik*, 38 (6), 482–487.

[38] Richardson, P. W., 2004: Reading and writing from textbooks in higher education: A case study from Economics. *Studies in Higher Education*, 29 (4), 505–519.

[39] Riordan, J. E., and P. E. Noyce, 2001: The impact of two standards-based mathematics curricula on students' achievement in mathematics. *Journal for Research in Mathematics Education*, 32 (4), 368–398.

[40] Schmidt, W., C. McKnight, G. Valverde, R. Houang, and D. Wiley, 1997: *Many Aims, Many Visions: A Cross-national Investigation of Curricular Intentions in School Mathematics*. Vol. 1. Kluwer Academic, 198 pp.

[41] Schoenfeld, A., 1992: Learning to think mathematically: Problem solving, metacognition, and sense making in mathematics. *Handbook of Research on Mathematics Teaching and Learning*, D. Grouws, Ed., New York: Macmillan, 334–370.

[42] Shepherd, M. D., 2005: Encouraging students to read mathematics. *PRIMUS*, 15 (2), 124–144.

[43] Stewart, J., 2007: *Calculus*. 6th ed. Belmont, CA: Brooks-Cole, 1344 pp.

[44] Stewart, J., 2008: *Single Variable Calculus: Early Transcendentals*. 6th ed. Belmont, CA: Brooks-Cole, 912 pp.

[45] Sullivan, M., and M. Sullivan, III., 2007: *College Algebra*. Upper Saddle River, NJ: Prentice Hall, 840 pp.

[46] Swokowski, E., and J. Cole, 1997: *Fundamentals of College Algebra*. 9th ed. Pacific Grove, CA: Brooks-Cole, 672 pp.

[47] Triola, M., 2007: *Elementary Statistics*. 10th ed. New York: Addison Wesley, 912 pp.

[48] Varberg, D., E. Purcell, and S. Rigdon, 2007: *Calculus*. 9th ed. Upper Saddle River, NJ: Pearson Education, 864 pp.

[49] Wandersee, J., 1988: Ways students read texts. *Journal of Research in Science Teaching*, 25 (1), 69–84.

[50] Weinberg, A. and E. Wiesner, (In Press). Understanding mathematics textbooks through reader-response criticism. *Educational Studies in Mathematics*.

[51] Weiss, L. R., E. R. Banilower, K. C. McMahon, and P. S. Smith, cited 2008: Report of the 2000 national survey of science and mathematics education. [Available online at `http://2000survey.horizon-research.com/reports/status.php` (Accessed on July 14, 2010).]

[52] Wheeler, R., and E. Wheeler, 2005: *Modern Mathematics for Elementary Educators*. 12th ed. Dubuque, IA: Kendall-Hunt, 745 pp.

APPENDIX A: TEXTBOOK-USE JOURNAL TEMPLATE

Date	Time	What you Read	Reason for Using
10/5	*7 PM*	*2 example problems, chapter summary*	*Studying for an exam*

APPENDIX B: INTERVIEW PROTOCOL

1. Did your instructor ask you to use your book in specific ways?
   (a) If so, what did they ask you to do?
   (b) Do you think they wanted you to use the book in other ways but didn't explicitly require it?
2. When did you use your textbook most frequently
3. What parts of your textbook did you use?
4. If you read the chapter text, how do you read it? Do you browse, do you read multiple times, etc.?
5. What were your reasons to use your textbook
6. Did you ever use the answers to odd-numbered problems or a solutions manual? What did you use it for and how frequently did you

use it?

7. What do you look for in a textbook?
8. Do you think a professor being a good lecturer or not would affect how you use your textbook?
9. Are there specific ways the class is set up or run that would affect the way that you use your textbook?

   (a) If the course content is very different from what is in the book

   (b) If the course covers content in a different order than is in the book

10. Do you have any other comments about how you have used your math textbook that we haven't already covered?

APPENDIX C: Survey Instrument

1. Do you

- O Have your own copy of the textbook?
- O Share a textbook with a classmate?
- O Borrow a copy of the text from the library?
- O Use online notes posted by the professor?
- O Not use a textbook?

2.

In most chapters of the book do you look at the **Introduction**?

Not Applicable O No O Yes O

If "Yes" please fill in each circle that describes **when** and **why** you read the **introduction**:

Introduction	While Preparing for Class	While Doing Homework	While Studying for Exams	Other Times
Read for better understanding	O	O	O	O
Make sense of definitions or theorems	O	O	O	O
Rephrase/summarize text (for notes, homework, etc.)	O	O	O	O
Other Reasons	O	O	O	O

3.

In most chapters of the book do you look at the **Chapter Text**?

Not Applicable O No O Yes O

If "Yes" please fill in each circle that describes **when** and **why** you read the **Chapter Text**:

Chapter Text	While Preparing for Class	While Doing Homework	While Studying for Exams	Other Times
Read for better understanding	O	O	O	O
Look up definitions or theorems	O	O	O	O
Make sense of definitions or theorems	O	O	O	O
Rephrase/summarize text (for notes, homework, etc.)	O	O	O	O
Other Reasons	O	O	O	O

4.

In most chapters of the book do you look at the **Examples**?

Not Applicable O No O Yes O

If "Yes" please fill in each circle that describes **when** and **why** you read the **Examples**:

Examples	While Preparing for Class	While Doing Homework	While Studying for Exams	Other Times
Read for better understanding	O	O	O	O
Make sense of definitions or theorems	O	O	O	O
Rephrase/summarize text (for notes, homework, etc.)	O	O	O	O
Other Reasons	O	O	O	O

5.

In most chapters of the book do you look at the **Chapter Summary**?

Not Applicable O No O Yes O

If "Yes" please fill in each circle that describes **when** and **why** you read the **Chapter Summary**:

Chapter Summary	While Preparing for Class	While Doing Homework	While Studying for Exams	Other Times
Read for better understanding	O	O	O	O
Look up definitions or theorems	O	O	O	O
Make sense of definitions or theorems	O	O	O	O
Rephrase/summarize text (for notes, homework, etc.)	O	O	O	O
Other Reasons	O	O	O	O

6.

In most chapters of the book do you look at the **Homework Problems**?

Not Applicable No Yes
O O O

If "Yes" please fill in each circle that describes **when** and **why** you read the **Homework Problems**:

Homework Problems	While Preparing for Class	While Doing Homework	While Studying for Exams	Other Times
Read to see what ideas come up most frequently	O	O	O	O
Read/copy to complete homework	O	O	O	O
Other Reasons	O	O	O	O

7.

In most chapters of the book do you look at the **Answers to Exercises or Solutions Manual**?

Not Applicable No Yes
O O O

If "Yes" please fill in each circle that describes **how often** and **why** you read the **Exercise Answers**:

Exercise Answers	Always	Often	Sometimes	Rarely	Never
Check my homework	O	O	O	O	O
Check my understanding of problems that weren't assigned	O	O	O	O	O
Look up answers without solving the problems	O	O	O	O	O
Other reasons	O	O	O	O	O

8. How well do the course material and the textbook match? (You may fill in more than one circle.)

O	The course material closely follows the textbook.
O	The course material generally follows the textbook, but the course sometimes covers material in a different order from the textbook.
O	The course material generally follows the textbook, but the course sometimes covers different material from the textbook
O	The course frequently covers material in a different order from the textbook.
O	The course frequently covers different material from the textbook.

9. Please rate the following qualities of a textbook for their importance, with 5 being very important and 1 being not important:

	Not Important=1	2	3	4	5=Very Important
Explains the big ideas of the course	O	O	O	O	O
Explains the underlying concepts of problems we're working on	O	O	O	O	O
Gives lots of examples to help you understand the material	O	O	O	O	O
Gives lots of examples that you can use on the homework	O	O	O	O	O
Highlights important equations (and definitions) by making them stand out from the rest of the text	O	O	O	O	O

10. Please indicate how frequently your professor asks you to do the following:

	Every Day	Every Week	Every Month	Never
Read the chapter	O	O	O	O
Do homework problems from the chapter	O	O	O	O
Look up definitions/theorems	O	O	O	O
Look at examples in the text	O	O	O	O
Other ways of using the textbook	O	O	O	O

BIOGRAPHICAL SKETCHES

Aaron Weinberg completed his Ph.D. in the mathematics department at the University of Wisconsin-Madison in 2005, where he specialized in mathematics education. He currently teaches mathematics, statistics, and courses for future teachers at Ithaca College. His primary research interests involve understanding the ways students use representations to understand mathematics.

Emilie Wiesner is an assistant professor at Ithaca College. She received her Ph.D. in 2005 from the University of Wisconsin-Madison and subsequently was a Franklin Fellow at the University of Georgia-Athens. Emilie is interested in issues of teaching and learning in mathematics; she also does mathematical research on the representation theory of Lie algebras.

Bret Benesh is an assistant professor at the College of Saint Benedict and Saint John's University in Minnesota. He received his Ph.D. in 2005 under the direction of Nigel Boston at the University of Wisconsin-Madison, and he was a preceptor at Harvard University from 2005-2008. His primary research interest is finite group theory, although he also enjoys learning about issues in education and psychology that relate to student learning.

Tim studied mathematics education at the University of Wisconsin-Madison, where he received a Ph.D. in educational psychology and a masters degree in mathematics. He currently is an Assistant Professor at Wright State University, where he studies the ways undergraduate students conceptualize limits in calculus. Tim also enjoys writing puzzles for his Knossos Games column in Imagine magazine, and is an avid hiker and cinephile.