

Instructor Use of Dynamic Textbooks in Teaching Linear Algebra and Abstract Algebra

Angeliki Mali and Vilma Mesa
School of Education, University of Michigan

Abstract

In this poster, we present two analyses of two dynamic textbooks: Judson's *Abstract Algebra: Theory and Applications* (AATA), and Bezeer's *A First Course in Linear Algebra* (FCLA). One analysis attends to their dynamic features, the mathematical practices embedded, and the scope of contents. The second analysis uses the documentational approach (Gueudet & Trouche, 2009) to investigate the ways in which these textbooks are used by instructors and their students. Data collection involves seven instructors and nearly 150 students across four states (New York, Texas, California, and Michigan; 50% female, 30% non-Caucasian or Asian) and surveys, logs, student tests, classroom observations, and clinical interviews. We found that instructors took advantage of the features only when those could be integrated into their usual practices.

Context & Research Questions

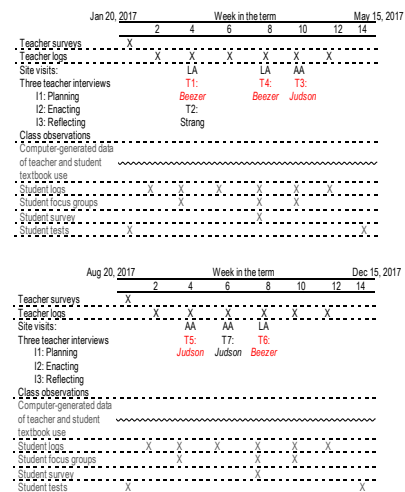
Even though the textbook continues to be one of the most important resources for instructors, textbooks enhanced with technologically advanced features are still in their infancy. In Undergraduate Teaching and Learning in Mathematics with Open Software and Textbooks (UTMOST, Bezeer et al., 2016), we investigate whether and how instructors and students take advantage of features that are included in dynamic textbooks enhanced with Sage computational cells (Bezeer, 2015; Judson, 2017). In particular, we investigate the following research questions:

1. What are the features of the textbooks?
2. How do instructors take advantage of the textbook features?

Data Collection

- Seven volunteer instructors (one female, five Caucasian), and their students.
- Data sources include:
 1. bi-weekly logs
 2. surveys
 3. video recordings of the planning and the enactment of lessons
 4. interviews
 5. tests of content knowledge
 6. computer-generated data analytics

Table 1 – Breakdown of data collection across two terms



Key
Red: HTML textbook format
Grey: Student data sources

Theoretical Underpinnings

Using the documentational approach (Gueudet & Trouche, 2009) we analyzed two processes, instrumentation (how the textbooks "affect" the instructor) and instrumentalization (how the instructor "affects" the textbooks), present when instructors used the textbooks for planning and teaching.

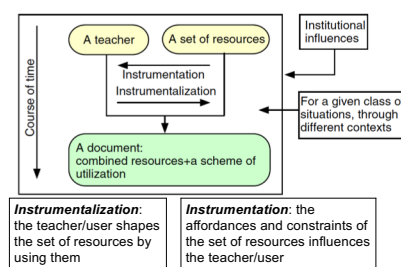


Figure 1 – Documentational Approach (Gueudet & Trouche, 2009)

Textbook Analysis

1. What are the features of the textbooks?

- Identification of textbook features in research literature (e.g., Usiskin, 2017, May)
- Use of computer-generated data to identify textbook chapters that have been heavily used from students
- Line-by-line analysis of those chapters (linear independence and basis, for FCLA, and groups, for AATA)

Table 2 – The features of the textbooks organized in three categories.

Category of textbook features	Definition of category	Textbook features
Dynamic features	Built-in digital features offering new types of user interface in terms of navigation, computation, and text modification	Table of contents, Index, Prev/Up/next buttons, Search engine Knows & cross referencing (Figure 2) Sage cells (Figure 3) Open source
Scope of contents (Usiskin, 2017)	Textbook content and author intention	Definition, Proof, Theorem End of chapter question/exercise, Example, Hint or worked out answer Introductory summary of section, Metaphor, Purpose Algorithm—utilizing procedures Deduction—the standard by which we decide whether a statement is true or not Representation—the result of the move from one mode of describing a piece of mathematics to another mode Symbolization—vocabulary and notation
Mathematical practices (Usiskin, 2017)	Ways of doing math	



Figure 2 – A know as a blue box embedded in text (Bezeer, 2017)

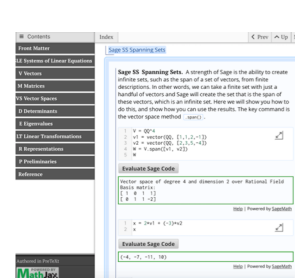


Figure 3 – Sage cells integrated in the HTML format (Bezeer, 2017)

Analysis of Textbook Use

2. How do instructors take advantage of the textbook features?

- Spectrum of textbook use from extensive to minimal.
- A case of extensive use of textbook's dynamic features:

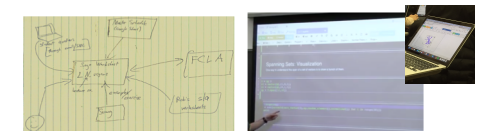


Figure 4 – Diagram of resources / Lecture notes embedded in Sage worksheet / Student work

Central resource: Sage worksheet in CoCalc

Utilization scheme of central resource: Creation of lecture notes from FCLA

Operational invariant: The geometric interpretation in \mathbb{R}^3 with more than two vectors linearly dependent better reveals the concept of linear dependence than the technical definition of linear combinations being zero. (Interview 2)

Instrumentation: The textbook examples do not include geometric visualization

Instrumentalization: The instructor uses a secondary resource—Strang textbook—for ideas of and applications with visualization

Discussion

- Novel use of the textbook features was not as extended, in part, because the instructors lacked familiarity with, or experience using, the features embedded in the textbooks.
- Instructors took advantage of the features only when those can be integrated into their usual practices.
- All the participant instructors used their textbooks to create their lecture notes attending to the sequencing of topics presented in the textbooks and maintaining the notation, definitions, and theorems. Their lecture notes nevertheless included either different proofs (because the proofs provided were not satisfactory for the instructors) or additional examples (because the ones available in the textbook were not contextualized or had no geometric visualization).

Next Steps

- Development of methods for collection of student data about textbook use: Connection between computer-generated data analytics and student self-reports in bi-weekly logs
- Analysis of other cases in the spectrum of textbook use.
- Refinement of our instruments to capture good descriptions of user interaction as related to teaching and learning in these environments.
- Use of the instruments in a larger project that will also investigate correlations of textbook use and student learning.

References

Bezeer, R. (2015). First course in linear algebra. Gig Harbor, WA: Congruent Press. Available at <http://linear.pugetsound.edu>, HTML available at <http://linear.us.edu/html/fcla.html>.

Bezeer, R., Judson, T., Farmer, D., Morrison, K., Mesa, V., & Lynds, S. (2016). Undergraduate Teaching in Mathematics with Open Software and Textbooks (UTMOST): National Science Foundation (DUE 1625223, 1626455, 1624634, 1624998).

Gueudet, G., & Trouche, L. (2009). Towards new documentation systems for mathematics teachers? *Educational Studies in Mathematics*, 71, 199-218.

Judson, T. (2017). *Abstract algebra. Theory and applications*. Available at <http://abstract.rogersound.edu>, HTML available at <http://abstract.us.edu/html>

Usiskin, Z. (2017, May). Electronic vs. paper textbook presentations of the various aspects of mathematics. Paper presented at the International Conference on Mathematics Textbook Research and Development II, Rio de Janeiro, Brazil.

Acknowledgements: This material is based upon work supported by the National Science Foundation (IUSE 1624634). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.