THE ROLE OF TECHNOLOGY FOR LEARNING STOCHASTICS IN U.S. TEXTBOOKS FOR PROSPECTIVE TEACHERS

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INTRODUCTION

Professional organizations have advocated for the use of electronic technologies in the teaching and learning of mathematics

- International Society for Technology in Education (2007, 2008)
- National Council of Teachers of Mathematics (2000)
- Conference Board of the Mathematical Sciences (2012)

An ever-growing number of technological resources are available to both students and teachers

- Content-generic (e.g., tablets, SMARTBoards)
- Mathematics-specific (e.g., calculators, software packages, apps)

INTRODUCTION

Several different types of technology may be used in teaching and learning topics in stochastics (i.e., probability and statistics).

- Handheld calculators may be utilized or pre-programmed to compute measures of centre.
- Spreadsheets have capabilities to quickly produce graphical displays.
- Some software programs allow the user to design and run simulations.

Prospective elementary teachers need experiences technology in order to develop their technological pedagogical content knowledge.

- In the United States, such experiences may occur within a mathematics content course.
- Mathematics textbooks are commonly used in such courses.

RESEARCH QUESTION

How is technology utilized and portrayed within chapters related to stochastics in mathematics textbooks for prospective elementary teachers in the United States?

ELEMENTARY TEACHER PREPARATION IN THE U.S.

An individual who wishes to become a teacher in a public school must earn

- a bachelor's degree and
- a teaching certificate.

Elementary schools typically house students from kindergarten (age 5) through grade 5 (age 11)

- Structures vary by state, district, and school

The majority of teachers in elementary school have a degree in elementary education (Dossey, Halvorsen, & McCrone, 2012).

ELEMENTARY TEACHER PREPARATION IN THE U.S.

Undergraduate programs in education vary by institution (National Council on Teacher Quality [NCTQ], 2008).

Programs often prescribe courses in both mathematics content and methods of teaching mathematics.

Content courses are offered by mathematics departments, e.g.,

- *Mathematics for Elementary Teachers I*
- *Geometry for Elementary Teachers*

Methods courses are offered in schools of education, e.g.,

- *Teaching Mathematics in the Elementary Classroom*
- *Learning and Teaching Number and Operations*

ELEMENTARY TEACHER PREPARATION IN THE U.S.

The Conference Board of the Mathematical Sciences (2012) recommends elementary teachers take 12 semester hours (540 classroom hours) of mathematics content from a teachers' perspective

A typical program requires 6 hours of content courses and 3 hours of methods courses (NCTQ, 2008).

TYPES OF TEACHER KNOWLEDGE

One goal of teacher preparation programs – spanning both content and methods courses – is the development of pedagogical content knowledge.

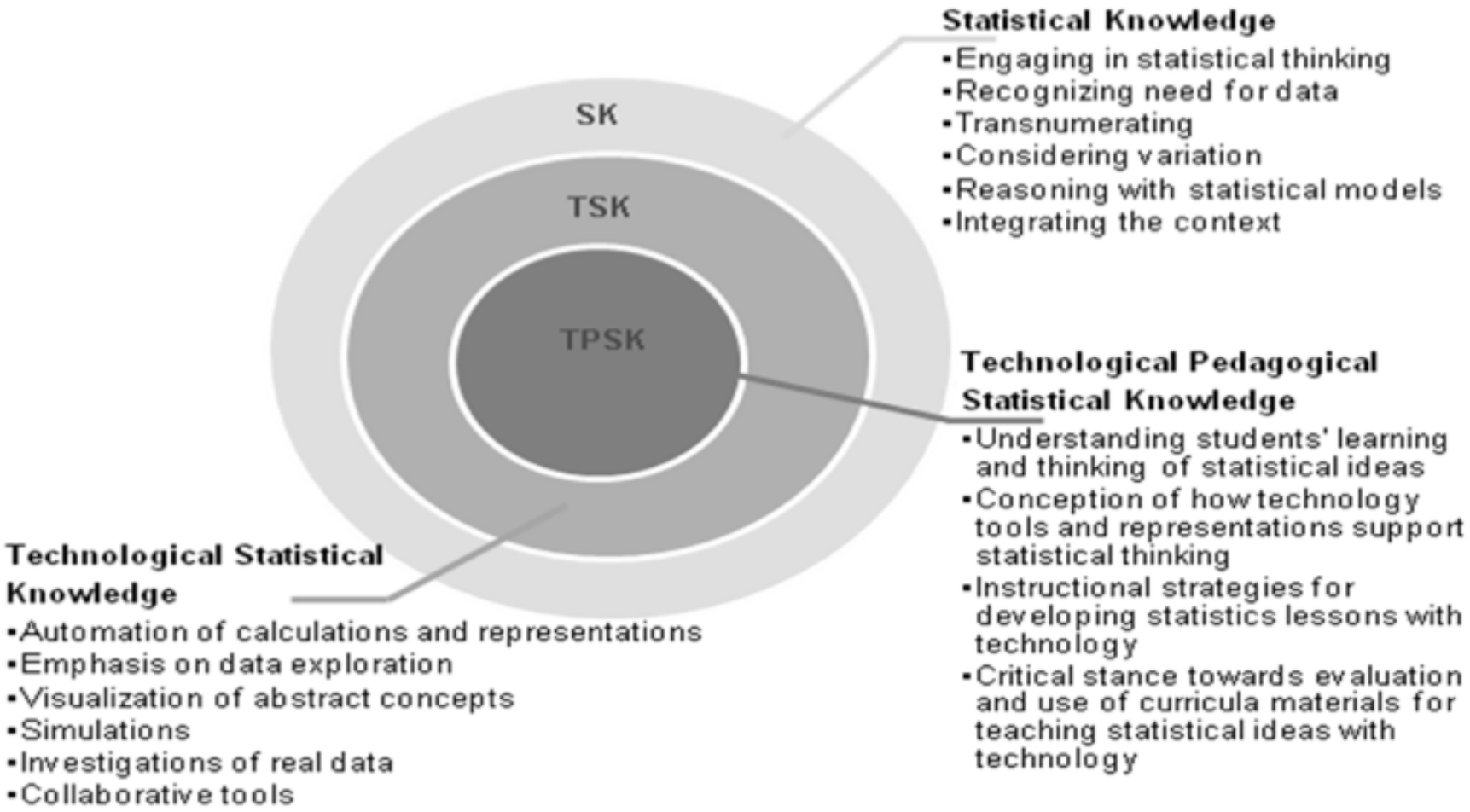
> "… a second kind of content knowledge…, which goes beyond knowledge of subject matter per se to the dimension of subject matter knowledge *for teaching*" (Shulman, 1986, p. 9).

This has been expanded and built upon to develop the construct of technological pedagogical content knowledge.

> "… the integration of development of knowledge of subject matter with the development of technology and of knowledge of teaching and learning" (Niess, 2005, p. 510).

TYPES OF TEACHER KNOWLEDGE

Lee and Hollebrands (2011) applied this model to statistics.



RELATED TEXTBOOK RESEARCH

Research on textbooks used in mathematics content courses for prospective elementary teachers in the U.S. is scarce.

Three notable examples:

- McCrory's (2006) comparison of textbooks written by research mathematicians to those written by others
- The NCTQ (2008) study of 77 U.S. teacher preparation programs
- The examination of the treatment of reasoning-and-proof by McCrory and Stylianides (2014).

In each of these studies, the authors examined between 16 and 20 textbooks used in mathematics content courses for elementary teachers – nearly the entire population of such textbooks.

METHODOLOGY: SAMPLE

Bas Bassarear, T. (2008). *Mathematics for elementary school teachers* (4th ed.). Boston: Houghton Mifflin.

Bec Beckmann, S. (2014). *Mathematics for elementary teachers with activities* (4th ed.). Boston: Pearson.

BLL Billstein, R., Libeskind, S., & Lott, J. W. (2010). *A problem solving approach to mathematics for elementary school teachers* (10th ed.). Boston: Addison Wesley.

LDM Long, C. T., DeTemple, D. W., & Millman R. S. (2012). *Mathematical reasoning for elementary teachers* (6th ed.). Boston: Addison Wesley.

MBP Musser, G. L., Burger, W. F., & Peterson, B. E. (2011). *Mathematics for elementary teachers: A contemporary approach* (9th ed.). Hoboken, NJ: John Wiley & Sons.

SSN Sowder, J., Sowder, L., & Nickerson, S. (2014). *Reconceptualizing mathematics for elementary school teachers* (2nd ed.). New York: W. H. Freeman and Company.

METHODOLOGY: CODING

For each textbook in the sample, the chapters related to stochastics were identified from the table of contents.

Each page within these chapters was examined for references to technology.

References were identified when:

1. the word “technology” appeared,
2. a specific type of electronic technology was mentioned, or
3. a portion of text was marked with a technology-related icon (e.g., a calculator or computer mouse).

Internet addresses (URLs) were included when students were directed to view the content therein, but not when the URL was provided solely to cite the source of a dataset.

METHODOLOGY: CODING

Each reference was classified by

- type of technology (e.g., calculator, spreadsheet, internet application)
- location
    - main text
    - auxiliary text
    - activity

Each references located in an activity was further coded as to whether the use of technology was *required* or *optional*.

RESULTS AND DISCUSSION

The textbooks within this sample displayed considerable variation along the coded dimensions.

		Number of references to technology				
Text book	Proportion of pages referencing technology	Main text	Auxiliary text	Activity (required)	Activity (optional)	Total
Bas	4 out of 118 (3.4%)	1	2	1	0	4
Bec	6 out of 124 (4.8%)	2	2	4	0	8
BLL	9 out of 163 (5.5%)	3	3	3	4	13
LDM	6 out of 115 (5.2%)	2	0	7	0	9
MBP	21 out of 140 (15.0%)	0	5	24	0	29
SSN	27 out of 174 (15.5%)	6	0	20	20	46

RESULTS AND DISCUSSION

Across the textbooks in the sample, technology was used to collect and manage data, generate random numbers to conduct simulations, create graphical displays, and compute values such as percentages, factorials, standard deviations, or equations of regression lines.

Most textbooks provided specific directions for performing a task with a specific type of technology.

- These types of references occurred within the main text of BLL and LDM and the auxiliary text in Bas, BLL, and MBP.
- SSN offers such instructions on its companion website, which was not examined for this study.

In BLL and SSN, about half of the activities or exercises that were analysed provided the option of using technology; in almost every case, these tasks were set in the context of conducting simulations, and included a table of randomly selected digits as a non-technological option.

With respect to the types of technology:

- Each textbook in the sample addressed the use of calculators
- Spreadsheets were mentioned by each textbook in the sample with the exception of Bec.
- Four textbooks (Bec, BLL, MBP, and SSN) directed students to use web-based applications
- Three textbooks (Bas, Bec, and SSN) required the internet to download data.

IMPLICATIONS FOR THE DEVELOPMENT OF TSK

These references primarily addressed the development of TSK.

- Students are provided with opportunities to use technology to perform tasks related to stochastics.
- This emphasis seems appropriate for the goals of content courses.

Furthermore, three of the textbooks in the sample (LDM, MBP, and SSN) provided guidance in interpreting apparently different results that arise from using different types of technology.

- This may also impact a prospective teacher's TSK.

Nevertheless, these six textbooks may not have similar influences on a teacher's TSK.

DESCRIPTIVE PROFILES

Bas: There were very few references to technology; the two references to specific technologies addressed downloading data and calculating percentages.

Bec: Five out of eight references directed students to download data.

BLL: Technology references emphasized using a calculator to generate random numbers and compute factorials, summary statistics, and data displays.

LDM: Referred to using a calculator for computing factorials and standard deviation, and used spreadsheets to conduct simulations.

DESCRIPTIVE PROFILES

MBP: Technology references focused on using *e-Manipulatives*, located on the book's companion website, to construct data displays and conduct simulations.

SSN: This textbook contained the greatest variation of types of technology, where prospective teachers (or their instructors) were given several options to conduct simulations, construct data displays, and compute summary statistics; these options included calculators, spreadsheets, dynamic statistical software packages, and open-access web applications from the National Council of Teachers of Mathematics.

IMPLICATIONS FOR THE DEVELOPMENT OF TPSK

On the whole, it was difficult to determine how or whether any of the references in these textbooks would affect the development of TPSK.

Two candidates occurred in Bec, with links to reports from professional organizations that address the teaching and learning of stochastics.

LIMITATIONS OF THE STUDY

One limitation of this study lies in the sample. While the most commonly-used textbooks were selected for this study, a number of other textbooks (at least ten) are available for mathematics content courses for prospective elementary teachers.

Furthermore, an instructor may choose not to use any particular textbook, and textbooks do not dictate what occurs in the classroom. An individual instructor may supplement a textbook to enhance the use of technology, or he may choose to ignore some or all of the technology references.

This study does provide a comparison of textbooks as they are written. As textbooks may influence an instructor's decisions, provide structure to courses, and serve as a reference to students, such a study serves as one measure of what may occur in classrooms.

CONCLUSION

Not all mathematics textbooks for prospective elementary teachers are the same.

This study highlights the variation in the extent and nature of the use of technology in teaching and learning stochastics.

It is important to note that these findings provide a description, but not an evaluation, of the textbooks in the sample.

Nevertheless, if the goal is to develop technological pedagogical content knowledge within prospective elementary teachers, textbooks should provide multiple opportunities which utilize different types of technology within all content areas – including, but not limited to, stochastics.

REFERENCES

Conference Board of the Mathematical Sciences. (2012). *The mathematical education of teachers II.* Providence, RI and Washington DC: American Mathematical Society and Mathematical Association of America.

Dossey, J. A., Halvorsen, K. T., & McCrone, S. S. (2012). *Mathematics education in the United States 2012: A capsule summary fact book*. Reston, VA: National Council of Teachers of Mathematics.

International Society for Technology in Education. (2007). *ISTE standards for students*. Eugene, OR: Author.

International Society for Technology in Education. (2008). *ISTE standards for teachers*. Eugene, OR: Author.

Lee, H. S., & Hollebrands, K. F. (2011). Characterising and developing teachers' knowledge for teaching statistics with technology. In C. Batanero, G. Burrill, & C. Reading (Eds.), *Teaching statistics in school mathematics – challenges for teaching and teachers education: A joint ICME/IASE study.* Dordrecht, The Netherlands: Springer.

McCrory, R. (2006). Mathematicians and mathematics textbooks for prospective elementary teachers. *Notices of the AMS, 53*(1), 20-29.

McCrory, R., & Stylianides, A. J. (2014). Reasoning-and-proving in mathematics textbooks for prospective elementary teachers. *International Journal of Educational Research, 64*, 119-131.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics.* Reston, VA: Author.

National Council on Teacher Quality. (2008). *No common denominator: The preparation of elementary teachers in mathematics by America's education schools*. Retrieved from http://www.nctq.org/p/publications/docs/nctq_ttmath_fullreport.pdf.

Niess, M. L. (2005). Preparing teachers to teach science and mathematics with technology: Developing a technology pedagogical content knowledge. *Teaching and Teacher Education, 21*(5), 509-523.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4-14.