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SoTL Tales: Lessons and Reflections from the Mathematics Classroom

A Review of *Doing the Scholarship of Teaching and Learning in Mathematics* edited by Jacqueline M. Dewar & Curtis D. Bennett

PREAMBLE

This is a fascinating book of fifteen SoTL stories – drawn from classroom experiments in the teaching of mathematics. The editors, Jacqueline Dewar and Curtis Bennett, have gathered within the covers of one book the adventures undertaken by math educators from various institutions in the US. This book provides both the SoTL readers and practitioners in math (and in other fields) with a wonderfully wide-ranging resource. The authors have also provided within the first four chapters (and a final brief epilogue, Chapter 20) an invaluable introduction to 'SoTL basics' that is particularly useful for those of us who count ourselves as newcomers to SoTL. The 'SoTL basics' describe the distinction between good, reflective teaching, scholarly teaching, and the *scholarship* of teaching and learning; the taxonomy of SoTL questions (Hutchings, 2000); how to get started in doing SoTL; and what (quantitative and qualitative) data may be collected for doing a SoTL investigation. The lessons to be learnt are numerous. In this short review, we can draw on only a few that appear most striking to us.

The three of us came to this work from three disciplinary domains: linguistics/gender studies, mathematics, and statistics. Our relative distance from mathematics means that we have slightly different ways of looking at this work as we privilege specific details that strike each of us as most educational from our own standpoint. In this review, we wish to offer our reflections on the lessons we took away from viewing the mathematics classroom from within and without, and provide a critique of these experiments on "doing SoTL in math."

THREE TAKES ON DOING SoTL IN MATHEMATICS

Take 1, from linguistics

For someone trained in linguistics/language and gender studies, two themes in this book – Theme 2, *Crafting learning experiences around real-world data or civic engagement* (Chapter 10 by Cindy Kaus, Chapter 11 by Michael Burke, and Chapter 12 by John Holcomb) and Theme 5, *Tackling large questions* (Chapter 18 by Curtis Bennett and Jacqueline Dewar and Chapter 19 by Rikki Wagstrom) – proved to be of particular interest *and* a very pleasant surprise. A governing stereotype about mathematics and statistics is that these are highly technical and opaque subjects that appeal to a very special group of people, and this belief is often reinforced by the way these subjects are taught. Furthermore, colleagues teaching math have lamented on the one hand that their math and stats classrooms are lacking in active engagement and on the other, have for the most parts, kept their in-class tutorial activities to 'solving complex equations' as opposed to engaging students in discussion, the latter being an activity that is more closely associated with humanities classrooms. It is, therefore, an eyeopener to read in these chapters that fairly successful attempts have been made to engage math and stats students through civic activities (e.g., incorporating "community-based group projects" in teaching statistics in Chapter 10; and integrating civic issues in teaching Algebra in Chapter 19). In addition to this – and this is the pleasant surprise alluded to earlier – it appeared that the training in math has helped to cultivate good writing skills and confidence in math majors (see Chapters 11 and 18), and that the use of "real-world data" helped to improve student engagement (Chapter 12) with math. This is heartening news from the math-SoTL classrooms. It shows that there can be very active and fruitful ways of teaching these technical fields. More importantly, these approaches open avenues for interdisciplinary collaborations between these fields and language/literacy studies and civic engagement.

A varied student profile, low retention rates, inadequate preparation in math/stats, and an overall "mathematics anxiety" served as the primary motivations for Cindy Kaus' attempt to integrate community-based civic engagement project work in her teaching of statistics (Chapter 10), an idea that she picked up from the NSF-funded curriculum, *Science Education for New Civic Engagements and Responsibilities* (SENCER) (p. 99). By encouraging her students to gather and analyse real-world data, whether it is about mercury levels in their living environment or domestic abuse in their community, students acquire stats skills through handling data that have direct relevance to their personal lives. Such real-life applications and resonance led to "large gains in students' confidence in their ability to understand statistics and its applications" (p. 102). Like Kaus, Rikki Wagstrom (Chapter 19) also attended a SENCER session and came away asking if "teaching algebra through civic issues [would] affect students' abilities to apply appropriate mathematical arguments or tools to mathematics-related problems arising in their lives?" (p. 191). Again, like Kaus, Wagstrom also found a significant increase in students' confidence in math and better quantitative reasoning skills in her treatment group.

While better math/stats engagement is a critical goal in these studies and I applaud the active engagement and good outcomes that have resulted from the creative deployment of these techniques, what got my attention is Bennett's and Dewar's findings in Chapter 18 relating to "The question of transfer: Investigating how mathematics contributes to a liberal education" (p. 183-189). As a language practitioner, it is thrilling for me to discover that the rigorous training in presenting mathematical proofs and reasoning has translated into better and disciplined writers among math majors as they (perhaps unconsciously) transferred the mathematical skills of conciseness and precision into their writing projects (p. 186). As the authors themselves observed, "While we always believed that learning mathematics helps students become better problem solvers and more logical, it was a surprise that so many students saw their mathematics major as helping them learn to write" (p. 188). As a teacher myself, I can fully share in the authors' (and the students') delight at this transferability of skills across disciplines, and the prospect for interdisciplinary collaborations. Two students said it best when they described the discipline instilled into their writing as a result of their mathematical training, as follows:

> *"I find how I write papers now is very mathematical – very scary."*
> *"When I write papers, I almost write like a proof. I think of what I know at the beginning and set that up, and then I progress through it and manipulate it until I get my end results or what I want." (p. 185)*

In sum, the lessons learnt from outside the standpoint of mathematics are: These authors have demonstrated that math classes do not have to be technical and devoid of real-life relevance; and there are possible connections between cultivating math skills and skills we think of as the purview of other disciplines.

Take 2, from within mathematics

I have been teaching mathematics for almost twenty years. Over the years, I have been reflective in my teaching, trying out different ideas and approaches with the aim to improve students' learning. It was not until recently that I started to move from being a reflective teacher to a scholarly one, after I was introduced to SoTL. Like many authors in this book, I am keen to work on some projects based on my classroom practices using SoTL approaches. Therefore, it is both exciting and welcoming for me to learn about this book that is specifically about doing SoTL in mathematics. In particular, I find the articles under Theme 1, *Experiments with approaches to teaching* (Chapters 5 through 9), and Theme 3, *Using assigned reading questions to explore student understanding* (Chapters 13 and 14), useful and appealing to me. My math classes are usually large with a few hundred students, while those mentioned in these chapters are typically small classes with twenty to thirty students. Nevertheless, many of the issues raised by the authors resonate well with me, and I find the studies quite applicable to my own teaching.

Like Gretchen Rimmasch and Jim Brandt (Chapter 5), I believe many math teachers agree that computational fluency is fundamental to learning a topic in math. It is "part of the culture of mathematics, [and] so teachers need to help students develop their procedural skills" (p. 56). Rimmasch and Brandt found that "visual cue" is effective in helping weaker students to attain the skill. This approach can be applied to many computational procedures that students find confusing. In fact, many math teachers have tried using visualization in their teaching one way or another when they encounter topics or concepts that students find challenging or too abstract to understand. These approaches could probably be investigated in a scholarly fashion, as these authors did, to ascertain their effectiveness.

A common problem faced by math teachers is that some students lack the motivation to do their homework assignments and have the tendency to work on them near to the submission dates. Lynn Gieger, John Nardo, Karen Schmeichel and Leah Zinner (Chapter 7) aimed to assess the effectiveness of an online homework system in a calculus class. The outcomes were encouraging: students were working on homework more frequently and practising problems on a more regular basis; and students also prefer online homework over regular forms as the former can provide them with more timely feedback. However, the authors also warned that the online system could "affect [the students'] personal connection to the instructors" (p. 72). These findings are useful references for math instructors who may like to explore alternative ways to motivate their students to do more practice exercises.

As mentioned above, another issue is the lack of interaction among students in math classes, even when the class sizes are small. Tutorial/discussion sessions are meant for students to discuss mathematics, with the aim of developing their communication and collaborative skills, but they usually end up with the tutors teaching rather than facilitating discussion. Edwin Herman (Chapter 8) gave a nice account of his carefully designed experiment to incorporate gameplay as part of his classroom activity. He found that "although [the exam scores do] not demonstrate that classroom games improve learning, [they suggest] that the time spent on games does not harm student learning and may improve student enjoyment of the course" (p. 81). Herman believed that "game use fostered a more communal learning environment" and "students … seemed less afraid of asking questions in class than students in similar courses" (p. 83).

In order for our math students to become independent learners, it is important for them to be able to read mathematical texts. However, many students do not read adequately, partly due to a lack of reading skills. To encourage their students to read, Mike Axtell and William Turner (Chapter 14) assigned pre-class reading and followed up with some reading questions and quizzes. I find this an effective way to motivate students to read the text. The aim of their study was to determine "what types of reading questions best facilitate independent learning, and the retention of the material learned, in our students?" (p. 138). Their findings indicated that "students are best able to retain knowledge that required some thought to understand (computational and conceptual questions) and least able to retain casually read and copied material (definitional questions)" (p. 140). This is useful information for teachers who are keen to try out pre-class reading questions.

I believe the above issues (as well as many others mentioned in the book) are faced by math teachers universally. That makes it all the more significant as part of the process of SoTL for these authors to 'go public', to disseminate their findings and share their experiences with the community of practice across the world. For me, the additional takeaways from these chapters are the various methodologies, in particular the collection and analysis of qualitative data that many math researchers are not familiar with. The literature review and advice provided by the authors are also tremendously insightful and will serve as valuable resources for SoTL newcomers like me to embark on SoTL projects. I would like to end my segment with a quote from Herman:

> *"As you progress [on a SoTL project], you will discover better ways to ask questions – even better questions to investigate. You may or may not succeed in answering your original question in a satisfying way, but you will become a better researcher, and a better teacher, because of it." (p. 77)*

We cannot agree more.

Take 3, from statistics

My colleagues have discussed the strategies and interventions employed by various authors to improve students' mathematics skills, and the 'side benefits' this has towards cultivating good writing skills. Both of these are critical for learning statistics. My focus will be on two issues peculiar to statistics – that of the connection between statistics and real life applications and the issue of control groups.

Compared to mathematics, statistics by nature tends to have more obvious linkages to real-life issues. Yet the interface between theory and practice is fraught with subtle non-mathematical issues, many of which require judgements supported by domain knowledge. Therefore mastery of statistical theory is not sufficient for its appropriate application to real problems. The requisite skills need to be taught explicitly, unlike routine mathematical tasks such as calculating the derivative or the integral of a new function. From this perspective, both Cindy Kaus and John Holcomb (see Chapters 10 and 12) are to be congratulated for bridging this gap directly. Kaus' students practised deep civic engagement by proposing solutions, based on collected data, to practical problems faced by the community around the Metropolitan State University in Minneapolis, which culminated in an action letter to the potential beneficiaries of the projects. One of her objectives, to increase students' interest and confidence in their ability to do mathematics, was shown to be accomplished by two surveys on students' experience with the new course. Holcomb's main learning goals for his students were implementation and interpretation of summary statistics, including graphs, and of inferential statistics, more specifically formal hypothesis tests, including an awareness of the limitations of such tests. His strategy was to assign several projects on analysing real data throughout the course, and to incorporate such activities in take-home components of the mid-term and final examinations. Based on students' responses to detailed carefully crafted questions, he found the majority of students had a positive experience.

Who would or could argue against engaging real world problems in statistics education? Finding the evidence to support such an intervention can be tricky, however. For example, a control group can be hard to come by, as discussed by the two authors, and also by Jacqueline Dewar. Interestingly, Kaus seemed to have less difficulty on the ethics front. While her civic engagement was arguably more "real" than Holcomb's data analysis projects, the impact on the attitudes of students in the treatment condition was marginally more impressive than that in control. In contrast, since Holcomb measured competency in data analysis, he "came to believe that giving students an assignment of this magnitude and of such stakes without providing them sufficient practice, in the form of homework, would be unfair and unethical." Presumably, if Kaus had set out to assess the ability of students to solve real problems, she would have stumbled into a similar quandary.

Both Kaus and Holcomb illuminated the important issue of control groups, which was discussed in detail by Dewar, who covered many other important measurement issues in SoTL. Ideally, participants should be randomly assigned to control and treatment groups, and the subjects should be blinded to the treatment they receive throughout the experiment and not just in the beginning (as suggested on page 20). Random assignment is rarely practical or ethical, and blinding is quite a challenge. But important causal effects have been demonstrated in healthcare without randomised experiments, using numerous concordant observational studies done in various populations. However, the P value against the null hypothesis that the treatment has no effect is difficult to interpret if the experiment is not randomised or blinded (Freedman, 2007, p. 555). In other words, a P value calculation can be done by some mechanical application of formulae, but seeking an interpretable statistical significance is challenging because of the inherent limitation in the study design and not so much the small sample size.

While the use of real-life application is a positive in the teaching of statistics, the challenge presented by control groups and randomized trials is an issue that requires more attention. It is, however, encouraging to read the several experiments embarked on by the authors in this book. Together, they have provided readers like me with much food for thought as I continue to untangle the difficulties of teaching statistics in my own classroom.

FINAL REMARKS

This book is indeed a rich resource for all SoTL practitioners, new or established, for both mathematicians and practitioners in any other discipline. The joys and the pitfalls that were encountered by these scholars attempting to do SoTL in math provide us not only with a very good read but have triggered our own reflections as we progress deeper into our SoTL journey. This is a collection of papers that we would recommend unhesitatingly to anyone curious and/or interested in doing SoTL, in any discipline.

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