TEACHERS AS KEY STAKEHOLDERS IN RESEARCH IN STATISTICS EDUCATION

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Teachers and practitioners of statistics are an underutilized resource in research in statistics education. Historically practitioners have tended to be viewed as consumers of research by the educational research community rather than active participants in the generation of new knowledge about the teaching and learning of statistics. Recently researchers in mathematics education have begun to involve teachers more as key stakeholders in research in an effort to forge closer links between research and practice. A discussion of what it means for teachers to be key stakeholders in research is provided, along with some examples from recent research that involve teachers as key stakeholders. Research in statistics education can enrich the links between research and practice in teaching statistics by involving statistics teachers as key stakeholders.

INTRODUCTION

Historically researchers have viewed teachers, students, and classrooms as sources of data to be observed and experimented with. Teachers have not often been involved in the design of the research, the generation of research questions, the analysis of data, or the dissemination of results. Researchers generate results and recommendations that they believe can be very helpful to classroom practitioners and lament the fact that more teachers do not know about their research or read their papers in research journals, and fail to implement important research findings. Meanwhile practitioners are heard to complain that research seems to pay little attention to their real concerns and questions about their teaching and about student learning. They claim that often research does not seem relevant to their situation.

TEACHERS AS STAKEHOLDERS IN RESEARCH

In their chapter in the *Third International Handbook of Mathematics Education*, Kieran, Krainer, and Shaughnessy (2013) analyze a growing trend in research in mathematics education to bridge the gap between research and classroom teaching practices by involving teachers in key ways in the research process.

> Despite these efforts and continuous claims on the importance of the role of teacher-researcher collaboration, teachers are still often seen as more or less passive recipients of researchers' knowledge production and sometimes as a means (e.g., as data supplier) to help produce knowledge. What is missing, in particular, is a systematic effort by the scientific community (such as societies, commissions, universities, research groups) to analyze and promote the potential role of teachers in research and its benefit for teachers and researchers. (p. 365)

Kieran et al identify five different roles that teachers can play in the research process, designating several of these roles as teachers participating in the research as "key stakeholders".

1. *Teachers as a means to access data*. In this role teachers are passive observers of the research process in which they, their students, and their classrooms provide the means for researchers to generate data to address a research question.
2. *Teachers as recipients of research results*. In this role teachers are either direct or indirect consumers of research—through journal articles, presentations at professional meetings, or research that has filtered down to their classrooms via mathematics supervisors, coaches, or administrators who are more familiar with the implications of some research on teaching and for classroom mathematics.
3. *Teachers as alumni of research projects*. In this role teachers who have themselves been subjects in research projects or whose students have been involved as subjects continue to implement tools or processes that were part of the research activity in their classrooms. Teachers may adapt research for their own curricular purposes or incorporate particular

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teaching moves or routines that the researchers were using with their students. Teachers are more likely to take on an active alumni role that continues the work started by researchers if they notice positive changes in student interest, attitudes, or achievement due to that research.

4. *Teachers as co-producers of professional knowledge*. Such knowledge includes both student and practitioner beliefs, conceptions, emotions, cognitions, interests and fears, as well as views of mathematics and mathematics teaching. In this role practitioners are experts on students' subject-related learning. They generate, reflect on, and make changes to their own and others' teaching practice.
5. *Teachers as co-producers of scientific knowledge*. In this role practitioners are involved in all aspects of a research project, including the goals of the research, formulating and revising research question, data gathering, data analysis, and dissemination of results.

In the first three of these roles teachers are primarily research objects themselves, or consumers of research. They are not actively involved in the research process or in the generation of and dissemination of new knowledge. Kieran et al consider teachers to be "key stakeholders" in roles 4 and 5 because they are active participants in the generation of new professional knowledge or new scientific knowledge.

EXAMPLES OF TEACHERS AS KEY STAKEHOLDERS IN PROFESSIONAL AND SCIENTIFIC RESEARCH

Lesson Study is one example of teachers involved as key stakeholders in the production of professional knowledge. There is a long-standing nationwide tradition in Japan of groups of teachers working together on (a) initial planning of a targeted lesson; (b) cycles of teaching, reflection, and revision; and finally (c) disseminating the process and the exemplary lesson developed (see for example, Krainer, 2011). Lesson study is a type of practitioner research in which the research question centers around the best way to teach a mathematical concept or process. The data are the lesson as taught, reviewed, revised, and taught again, followed by the scholarly activity of writing up and sharing the polished lesson. Lesson Study has been broadly adapted and is being implemented in various ways in the teaching of mathematics in many countries. In China Lesson Study was implemented on a very large scale when the National Mathematics Curriculum Standards ushered in a new set of curriculum guidelines emphasizing creative thinking, problem solving, and mathematical exploration (Huang & Bao, 2006). Teachers who experienced difficulty implementing the new Chinese standards subsequently worked with mathematics educators to link professional development and research on teachers' classroom practices (Li, Huang, Bao, & Fan, 2011). Communities of researchers and teachers involved together in action and reflection are an integral part of professional development in China.

Teachers' research on their own practice is another type of key stakeholder research that is becoming more common in recent years. In a four-year project teacher researchers collaborated with university researchers in reflecting on their own teaching and in conducting cycles of action research that focused on improving the mathematical discourse of their classrooms (Herbel-Eisenmann, 2010). In the book *Promoting Purposeful Discourse* (Herbel-Eisenmann & Cirillo, 2009) eight teachers document the cycles of action research they did over several years on topics such as: student participation in conceptual discourse; attending to particular performance gaps in their classroom practices that were discovered in their mathematics teaching belief maps; working on giving students more ownership in the mathematical discourse; thoughtful re-voicing of student questions; addressing vagueness in classroom mathematical discourse; and improving their own listening to students' mathematical discourse. At the same time university researchers were investigating what moves, actions, and support structures might be helpful to create an environment where teachers can become researchers themselves. The teacher researchers were conducting research on their classroom discourse behaviors and on patterns of student discourse interactions in their classrooms as they developed their own action-research projects. A "linking" of research and practice occurred continually throughout this project within the discussions and reflective activity during meetings of the teachers and university researchers. This project is an example of what Makar and O'Brien (2013) refer to as the "reflexivity" in research where both university researchers and teachers are co-producers of knowledge. Teachers can experience an "identity renegotiation" when they became aware of their research contributions to a project. Meanwhile, university researchers are experiencing their own growth in the role as a collaborative researcher with practitioners. The co-production of knowledge by teachers and researchers provides the opportunity for a *dynamic duality* where teachers become key stakeholders in the research process, and on the flip side, researchers become key stakeholder in the teaching process.

Teachers were key stakeholders in a statistics education research project that investigated conceptions of variability among age 12 to 18 students (Noll & Shaughnessy, 2012). Students' reasoning about variation was studied in three different contexts over a three year period: repeated sampling and sampling distributions; repeated measurement data; and co-variation over time within multivariate data sets about food consumption. Six classroom teachers teamed with five university researchers in most all aspects of the research. The teachers reviewed and commented on many of the research tasks and predicted how they expected their students would respond to the tasks. Teachers and researchers jointly created and then co-taught the week-long classroom teaching episodes designed around each of the three contexts involving variation. In the final year of the project the teachers also designed and conducted their own action research projects, wrote research papers about their studies (the question, the data, the analysis, and their results) and reported on their action research at a national professional meeting attended by both teachers and university researchers (Shaughnessy, 2007). Meanwhile the university researchers were heavily involved in teaching the exploratory episodes on variation to students in classes from a variety of schools (urban, suburban, rural) across a wide range of grade levels. The dynamic duality, or reflexivity described by Makar and O'Brien (2013), occurred in significant ways throughout this project because teachers were key stakeholders in the research pieces of the project and simultaneously the researchers were key stakeholders in the classroom teaching episodes in the project. Each community—researchers and teachers—generated both professional and scientific knowledge by working closely with the other.

There are at least three dimensions of teacher involvement as key stakeholders that can be discerned within the examples above (Kieran et al., 2013).

1. Reflective, inquiry-based activity by teachers with respect to teaching actions, such as in Lesson Study.
2. A significant teacher designed action-research component that is accompanied by the creation of research artifacts by teachers (sometimes assisted by university researchers in this process), such as tasks, student work samples, and analyses of student discourse.
3. The dynamic duality that occurs when researchers and teachers take on the roles and the work of their counterparts and experience growth and new learning within one another's area of expertise.

From teachers' point of view, Bednarz (2004) points out some common themes that contribute to teachers' professional development when they are key stakeholders in collaborative research, including:

- A deeper reflection on the content (mathematical, statistical) situated in practice
- A new awareness of the nature of mathematical or statistical activity through opportunities to discuss and debate
- New ways to look at students' claims, student discourse, and student productions through discussion and debate on student work
- Reflection on the didactical variables involved in a given task and subsequent analyses of tasks that moves away from superficial aspects towards a focus on student reasoning
- Teaching strategies, where the reasons for underlying decision-making moves made during teaching are rendered explicit, thereby opening up other points of view.

These themes identified by Bednarz figure prominently in an example of collaborative research among multiple stakeholders in which researchers and teachers are currently working collaboratively with school administrators and professional developers in an investigation of professional knowledge for teaching. The multiple stakeholders are co-producing scientific knowledge about critical factors involved in professional development. The National Science Foundation funded project *Enhancing Mathematics Teaching and Learning in Urban Elementary Schools (EMTL)* (Foreman et al, 2013*)* is a four year project that involves all the grade 3 – 5 teachers of mathematics in 27 elementary schools in a large urban school district, together with the school principals, the mathematics coaches in the schools, a university research team, and a highly experienced team of professional development consultants. In this project, all these groups—teachers, administrators, professional developers, and researchers—are key stakeholders. Everyone is involved in the research, the professional development, and in the co-production of both professional and scientific knowledge.

Teams of teachers work together with their administrators and professional development experts to implement classroom practices built around Mathematical Habits of Mind (MHoM), Mathematical Habits of Interaction (MHoI), and Mathematically Productive Teaching Routines (MPR). The MHoM are aspects of student reasoning and sense making, the MHoI are ways that students are involved in high quality discourse about mathematics, and the MPR are purposeful organizational teaching moves made by teachers to explicitly foster the MHoM and MHoI among their students. The MHoM include Justifying, Generalizing, Sense Making, Making Mathematical Connections, Looking for Structure, Reflecting on One's Thinking, Using Mistakes and Stuck Points, and Persevering. Among the MHoI are Private Reasoning Time, Explaining, Listening to Understand, Asking Genuine Questions, and Critiquing the Reasoning of Others. Examples of Mathematically Productive Teaching Routines are: Structuring Student Mathematical Talk; Selecting and Sequencing Student Work to highlight the Mathematics; Working with Public Records of Students' Thinking; and Working with Student Errors and Misconceptions to raise the level of student reasoning and the quality of their mathematical discourse. Of great interest to researchers, administrators, and the teachers themselves in this project is the process of documenting evidence on the implementation of the MHoMs, MHoIs, and MPRs in classrooms, and connections between their implementation and subsequent student growth in mathematical reasoning and achievement.

Among the tools that are being developed in the EMTL project is a classroom observational tool that can easily record instances, duration, and prevalence of students engaged in the Habits of Mind, the quality of their mathematical discourse when using the the Habits of Interaction, and explicit use by teachers of one or more of the mathematically productive teaching routines to foster student engagement in the MHoMs and MHoIs. The observation tool will be used for multiple purposes by the various stakeholders in the research. Researchers wish to document the implementation of the professional development as evidenced by student and teacher behaviors in classrooms. Principals will use the tool during their classroom walk-throughs for data snaps on how students are reasoning and making sense about mathematics, and how teachers are structuring lessons. And teachers will use the tool when visiting one another's classrooms to provide snapshots of the mathematical habits and teaching routines attention they notice as they learn from one another's practice. Thus, all parties in the project are considered key stakeholders in both the professional development and scientific research components of the project.

WHAT ABOUT TEACHERS AS KEY STAKEHOLDERS IN RESEARCH ON STATISTICS EDUCATION?

Most of the examples provided above of teachers engaged as key stakeholders in collaborative research are taken from mathematics education. This is likely due to targeted efforts within mathematics education in recent years to provide more explicit links between research and practice, to bridge the gap between researchers and practitioners. In 2008 the National (US) Council of Teachers of Mathematics (NCTM) obtained funding for a working conference that brought together researchers in mathematics education and highly recognized teachers of mathematics at all levels, elementary to post secondary, to develop a future research agenda that could address the burning questions that are of most importance to practitioners. The report of the NCTM (2010) *Research Agenda Project* identified ten key areas of research for researchers and practitioners to collaborate on and to concentrate their efforts over the next several decades. Under each of the ten key areas, teams of teachers and researchers generated lists of research questions that need to be systematically investigated over a period of time.

The groundwork lain by the NCTM Research Agenda Project, and the examples of teachers involved in collaborative mathematics education research provided above, raise some important questions for the future of research in statistics education. What are the most pressing areas for research in the teaching and learning of statistics from the practitioners' point of view? If a group of statistics education researchers and statistics teachers and practitioners were brought together for a similar research agenda project in statistics education, what areas would they identify as most in need of research? What research questions would they generate about those areas? With respect to student engagement in statistics, what would a corresponding list of the most important Statistical Habits of Mind look like (SHoM)? What would be included as Statistical Habits of Interaction (SHoI) that might characterize critical elements of discourse, argument, and discussion for statistics students? And, what would be at the top of a list of Statistically Productive Teaching Routines (SPR)? Perhaps the model of statistical thinking developed by Wild and Pfannkuch (1999) can provide some starting points for the statistics education community to generate Statistical Habits of Mind, and Statistically Productive Teaching Routines that are analogous to the mathematical habits and teaching routines identified by Foreman et al (2013).

CONCLUSION

Our counterparts in mathematics education have started to tap into that missing resource in their research—the perspective and collaborative power of teachers. Statistics educators would do well to think hard about ways to incorporate teachers as key stakeholders into their research as well, otherwise opportunities to establish critical links between research and practice in statistics education will continue to be untapped, and progress in the teaching and learning of statistics will be slower than it might be when researchers and practitioners collaborate. To paraphrase from the chapter by Kieran, Krainer, and Shaughnessy (2013): How can *statistics* education research have an impact on *statistics* classrooms, on students' learning, abilities, beliefs, and interests? And how can *statistics education* researchers benefit from the rich body of knowledge and subjective theories that *statistics* teachers have? And, who is responsible for dealing with this question?

REFERENCES

Bednarz, N. (2004). Collaborative research and professional development of teachers in mathematics. In M. Niss & E. Emborg (Eds.), *Proceedings of the 10th International Congress on Mathematical Education* (CD version, pp. 1–15). Copenhagen, Denmark: IMFUFA, Roskilde University.

Foreman, L., Fredericks, J., Noll, J., Thanheiser, E., & Shaughnessy, J. M. (2013). *Enhancing Mathematics Teaching and Learning in Urban Elementary Schools*. NSF EHR Grant No. DUE-1223074.

Herbel-Eisenmann, B., & Cirillo, M. (Eds.) (2009). *Promoting purposeful discourse. Teacher research in mathematics classrooms*. Reston, VA: National Council of Teachers of Mathematics.

Herbel-Eisenmann, B. (2010). Discourse analysis: A catalyst for reflective inquiry in mathematics classrooms. In *Linking research and practice: The NCTM Research Agenda Conference report* (pp. 36–37). Reston, VA: National Council of Teachers of Mathematics.

Huang, R., & Bao, J. (2006). Towards a model for teacher professional development in China: Introducing *keli*. *Journal of Mathematics Teacher Education, 9*, 279-298.

Kieran, C., Krainer K., & Shaughnessy, J. M. (2013). Linking research to practice: Teachers as key stakeholders in mathematics education research. In K. Clements, A. Bishop, C. Keitel, J. Kilpatrick, and F. Leung, (Eds.), *Third International Handbook of Research in Mathematics Education* (pp. 361 – 392). New York: Springer.

Krainer, K. (2011). Teachers as stakeholders in mathematics education research. In B. Ubuz (Ed.), *Proceedings of the 35th Conference of the International Group for the Psychology of Mathematics Education* (Vol. 1, pp. 47–62). Ankara, Turkey: International Group for the Psychology of Mathematics Education.

Li, Y., Huang, R., Bao, J., & Fan, Y. (2011). Facilitating mathematics teachers' professional development through ranking and promotion practices in the Chinese mainland. In N. Bednarz,

D. Fiorentini, & R. Huang (Eds.), *International approaches to professional development of mathematics teachers* (pp. 72-85). Ottawa, Canada: Presses de l'Université d'Ottawa.

Makar, K., & O'Brien, M. (2013). Blurring the boundaries: The *trans*formative nature of research participation. In W. Midgley, P. A. Danaher, & M. Baguley (Eds.), *The role of participants in education research: Ethics, epistemologies, and methods* (pp. 110-125). New York: Routledge.

National Council of Teachers of Mathematics. (2010). *Linking research and practice: The NCTM Research Agenda Conference Report*. Reston, VA: NCTM.

Noll J., & Shaughnessy, J. M. (2012). Aspects of students' reasoning about variation in empirical sampling distributions. *Journal for Research in Mathematics Education, 43*(5), 509–556.

Shaughnessy, J. M. (2007). *Exploring the development of secondary students' and teachers' conceptions of variability*. Final Report of NSF Grant No. REC-0207842.

Wild, C. J., & Pfannkuch, M. (1999). Statistical thinking in empirical enquiry. *International Statistical Review*, *67*, 223-265.