Interview with Mike Shaughnessy

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Beginnings

AR: Thanks very much, Mike, for agreeing to this interview for the Journal of Statistics Education. *The name of the journal leads to my opening question: Which came first – your interest in statistics, or your interest in education?*

MS: Actually my interest started with mathematics, first in high school and then as a mathematics major in college through the masters level. I became interested in how students think and learn when I was teaching mathematics courses as a college instructor. This motivated me to pursue further study in the (at that time rather new) field of mathematics education. When I was working on my doctorate in mathematics education I discovered that statistics and probability were particularly challenging areas to teach students, and also provided a laboratory of rich concepts to explore student thinking.

Research in Probabilistic Thinking

AR: Did your doctoral thesis involve probability/statistics issues? If so, what kinds of issues and challenges? (By the way, where did you pursue your doctorate?)

MS: While working on my doctorate at Michigan State University I participated in an interdisciplinary graduate seminar on Problem Solving and Decision-Making run by Professor Lee Shulman. Lee was a great teacher and mentor for me at MSU, and in the seminar he included some papers written by cognitive psychologists on decision making under uncertainty and on human judgment and intuition about chance events. At the same time I was teaching an undergraduate course in probability, and I found that my mathematics students had the same conceptions about chance events and decision-making under uncertainty as the subjects in those psychology studies. This got me interested in pursuing how students think and reason about situations where probabilistic or statistical reasoning could help solve problems or provide information for making decisions, and my thesis was about how undergraduates reasoned about chance, and whether an activity- and inquiry-based approach to teaching introductory probability and statistics could influence their reasoning.

AR: What did you learn? (Before giving you a chance to answer, I must admit that I'm sincerely hoping that you'll say that such a teaching approach can influence students' reasoning!)

MS: Well, yes, a teaching approach can influence *some* students' reasoning, but it isn't all black and white as I found out. Although the results of my approach were statistically significant, as a teacher I was disappointed that the approach wasn't closer to 100% effective in changing students' thinking. The lesson I learned is that people's intuitions and beliefs about probability and statistics are deeply entrenched, and that just because we might focus on a theoretically correct way for students to think about decision making under uncertainty doesn't mean that they will change their reasoning patterns. One course in statistical reasoning isn't enough to change all the students' beliefs.

AR: Is this the Kahneman-Tversky work that you were addressing? Can you give an example or two of the type of incorrect probabilistic reasoning that students were exhibiting?

MS: Yes, I first learned about the work on judgment and decision-making by Daniel Kahneman and Amos Tversky back in that seminar with Lee Shulman. Kahneman and Tversky were arguing that humans rely on certain helping heuristics when they need to make decisions or provide estimates that involve chance or uncertainty (Kahneman, Slovic, and Tversky, 1982). One of these heuristics they called 'representativeness,' in which people estimate the likelihood of an outcome based on how representative that outcome is of either the parent population, or of the process by which the outcomes are generated. For example, many people believe that if we toss a coin six times and record the sequence of heads and tails, that an outcome such as HTHHHT is less likely to occur than the outcome HTTHTH, because the latter sequence is more 'representative' of the uniform distribution of H's and T's in the parent population. Similarly, a sequence like HTTHTH would be deemed more likely to occur than say, HHHTTT, because the latter sequence just isn't 'random enough.' Indeed, a majority of my students did exhibit this kind of reasoning on such tasks given to them prior to any experience working with probability or conducting simulation experiments.

AR: The Kahneman-Tversky type of research into difficulties that people have with reasoning probabilistically and making decisions under uncertainty really fascinates me, and there has been considerable work in this area over the years. I enjoyed reading Kahneman's recent book Thinking: Fast and Slow *(2011). I have two follow-up questions related to this, based on (perhaps mistaken) impressions that I have. One impression is that considerably more work has been done with understanding people's difficulties with probabilistic thinking than with statistical thinking. My second impression is that relatively little research has been conducted into how best to help people to overcome their heuristics and biases and enable them to reason well under uncertainty. But let's see, I still have not asked a question. Do either of my impressions strike you as accurate? If so, why do you think there's been comparatively little work with statistical thinking and with overcoming misconceptions?*

MS: As with most impressions that we have about research, when we take a closer look the truth of what has or has not been done tends to be mixed, and this is also the case with your two impressions. Let me start with the impression that you have that comparatively little work in statistical thinking has been done when compared with research on probabilistic thinking. Twenty years ago that was definitely true. During my career I have had several opportunities to conduct detailed reviews of the educational research on probability and statistics. These reviews were published in the first and second *Handbooks of Research on Mathematics Teaching and Learning* respectively (NCTM, 1992, 2007). The first *Handbook* chapter (1992) provides evidence that up until the early 1990's, research in stochastical thinking (probability and statistics) was dominated by both cognitive psychologists and mathematics educators who were interested in documenting how students thought about chance and probability, and in some cases how instruction was able to impact students' conceptions and beliefs about probability. There were also a few studies at that time that dealt with overcoming misconceptions. However, over the subsequent twenty years there has been a huge swing in the research towards exploring students' statistical thinking and reasoning and statistical literacy. Research on students' statistical thinking at all levels (elementary, middle, secondary, tertiary) has been growing at a very fast rate, so much so that in the *Second Handbook* (2007) there were separate chapters devoted to research on probability and research on statistics. Substantial work has now been done on students' thinking about measures of center (e.g., Jan Mokros and Susan Jo Russell, (1995), Jane Watson and Jonathan Moritz (2000) among others); student thinking about variability (e.g., Jane Watson and many of her colleagues (2003), Chris Reading and myself (2004), myself and a team of researchers (2005)); and general models of statistical thinking, reasoning and literacy (Chris Wild and Maxine Pfannkuch (1999), Jane Watson and colleagues (2003), Graham Jones, Cindy Langrall and their team of researchers (2004)). I believe that the number of researchers in the world who are working on statistical thinking has now surpassed those who are working on probabilistic reasoning. The fact that both areas are very active was confirmed this past summer at the ICME 12 conference in Seoul, since there were separate working groups in both probability and statistics education that were very well attended by international delegates.

As for your impression that comparatively little work has been done in the area of 'overcoming misconceptions,' Jones, Langrall, and Mooney (2007) point out in their chapter on research on probability (in the *Second Handbook*) that most studies of students' thinking about probability have been done prior to instruction, and not enough work has been done documenting the effects of instruction in probability on changes in students' thinking, particularly at secondary and tertiary levels. Carmen Batanero and her colleagues in Spain, among others, have done considerable work in the area of students' probabilistic conceptions over the past twenty years, including student thinking about conditional probability and their reasoning about contingency tables (1996). So work on what has been referred to as 'misconceptions' has continued to attract researchers' interest. However the paradigm has changed among statistics educators from that early version of 'students' misconceptions.' The term misconception is probably not the best way for us to characterize student reasoning, because it describes a deficit model of student thinking. A more pro-active model is to consider students' conceptions as always being in transition, and that we as researchers and instructors have the opportunity to affect their conceptions, and open new ways of thinking about chance and data to our students. The current belief among researchers is that simulation approaches to probability and re-randomization techniques for hypothesis testing help change our students' thinking about probability and statistics. There have been some studies that have provided evidence that these approaches change student thinking. However, what is needed in our field now are statistical experiments—randomized design studies—that can test the hypothesis that simulation and re-randomization approaches can improve students' probabilistic and statistical conceptions. This was in fact one of the recommendations that came out of the Statistics Topic Group at ICME 12 in Seoul.

More Beginnings

AR: Thanks very much for that, Mike. Let me return to a biographical question: When you finished your Ph.D. at Michigan State, what kind of positions were you interested in? What opportunities did you pursue? Did you go directly to Portland State, or where did you go first?

MS: I received my Ph.D. in the mathematics department at Michigan State, and I was interested in designing different approaches to college mathematics and statistics courses, particularly in developing programs for prospective secondary mathematics teachers. I was also interested in doing further research on how undergraduate college and university students thought about and learned mathematics and statistics. So I was looking for a position as a mathematics educator within a college or university mathematics department. At the time that I finished my graduate work, there were very few such positions available. A position at Oregon State University in Corvallis, Oregon appeared among the job postings, and I could hardly believe it because that job seemed like it was written for a person just like me with my kind of academic background and interests. I applied for the position at Oregon State, as well as several other places that were looking for a mathematics educator and I was fortunate to be offered the job at OSU in the mathematics department. I spent the first twenty years of my career at OSU before moving to Portland State.

AR: Did you teach courses in both mathematics and mathematics education at Oregon State? Did you also teach any probability and/or statistics? What was your teaching style/approach at that time?

MS: At Oregon State I taught a wide range of mathematics courses, mostly for prospective secondary teachers: abstract algebra, Euclidean and non-Euclidean geometry, analysis, computers and mathematics, mathematical problem solving, graph theory, and probability. I also taught mathematics for elementary teachers, calculus, large lectures of pre-calculus, and even designed a problem solving approach to intermediate algebra. The Mathematics Education courses I taught were in graduate programs in the mathematics department, both in a Masters Program for Secondary Teachers, and eventually in a Ph.D. Program in Mathematics Education, where courses were conducted in a seminar approach, and students did a lot of the class leading. I really had hardly any opportunity to teach statistics while I was at Oregon State University, except in summer institute programs with teachers. I began to teach in a small group problem solving style while I was at Oregon State, and I used that method in many courses—abstract algebra, problem solving, mathematics for elementary teachers in particular. I was really interested in the research in mathematical problem solving at the time, and so I attempted to implement teaching approaches that mirrored the types of studies that were being reported in the problem solving research literature. That was the beginning of my transition from a lecture approach in college mathematics and statistics courses, to where I am today in my teaching style. But I still had a lot to learn about implementing thoughtful classroom interaction norms in those groups, having students listen to one another and honor one another’s approaches, and making sure that all voices in the classroom had opportunities to be heard and to participate. That part of my teaching didn’t really mature until I came to Portland State, where I had the opportunity to learn from some true master teachers.

AR: What prompted your move to Portland State, and what courses did you teach when you got there?

MS: Several life events converged to prompt the move to Portland State. For several summers I had been working on an NSF funded curriculum project with a team at PSU to develop a series of courses for middle school mathematics teachers. About the same time my wife landed a job at the Northwest Educational Regional Laboratory, and she was commuting from Corvallis to Portland several times a week. My two teen-age daughters were stuck with me in one of those classic “Mr. Mom” situations, so I took a one year leave from OSU to concentrate on the implementation phase of the curriculum project, and teach the initial versions of several of the new courses for middle school teachers at PSU. PSU asked me to stay on for another year. I had done about as much as I could at that time developing graduate education programs at OSU, and PSU was very interested in starting up a new doctoral program in Mathematics Education within the mathematics department. I had an opportunity at PSU to create and develop the kind of doctoral program in mathematics education within a mathematics content department that I had previously only been able to dream about, and I had a lot of freedom to try things at PSU. The transition took several years, though; I had to resign my position at OSU and go back through the whole tenure process once again. It took about 5 years to get the doctoral program in mathematics education past all the university and state system hurdles, but it was finally approved, and official, starting in the fall of 1997.

At PSU I taught mostly upper division mathematics, and graduate mathematics education and statistics courses within three graduate programs in the department: a graduate certificate program in Mathematics for Middle School Teachers (the program that resulted from the curriculum project that I been working on); the Masters of Science in Teaching Mathematics (MST) program for secondary mathematics teachers; and eventually courses in the new Ph.D. program in Mathematics Education. The courses I taught for Middle School teachers included statistics, geometry, algebra, problem solving, calculus, history of mathematics, and computers & mathematics for middle school teachers. The courses I taught for Secondary School teachers included statistics, probability, abstract algebra, analysis, and geometry for secondary mathematics teachers. I developed new doctoral courses in Research on Learning in Mathematics, Research on the Teaching of Mathematics, the History of Mathematics Education, Research Methodology in Mathematics Education, and special seminars devoted to research on the teaching and learning of statistics, and research on the teaching and learning of geometry. So you can see, I taught a wide range of courses at Portland State over a twenty-year period. However, I also worked on the vertical connections within content across the levels of middle school, secondary school, and doctoral level mathematics education, so that there was some overlap in tasks, readings, and classroom activities, to some degree, that I used or assigned in those courses.

Program in Mathematics Education

AR: That sounds like a lot of work but also sounds like a labor of love on your part to build that Ph.D. program in Mathematics Education. Let me expose my lack of knowledge about the field of Mathematics Education with some follow-up questions. What are the backgrounds of the students who enter the program? I suspect that there's a lot of variety there, but what are some common backgrounds?

MS: You are quite correct. Students come to our Ph.D. program from a variety of backgrounds. Some are specifically looking for a Ph.D. in mathematics education within a mathematics department. They wish to find a future position themselves within a mathematics department, and there have been more and more of these positions in mathematics education in mathematics departments appearing on the job listings over the past five years. They also may wish to study more mathematics themselves, while entering the field of mathematics education. Such students usually already have at least a Master's degree in mathematics when they come to us. Other students have been teaching secondary or middle school mathematics, have returned to PSU to do coursework in one of our programs for teachers—either the MST for secondary teachers, or the Middle School Mathematics Program—and become interested in research in mathematics education. We have had some of our own MST students decide to go on for a Ph.D. We've also attracted faculty from Community Colleges who are interested in learning more about mathematics education, and some of them have entered the doctoral program. In recent years there has been a growing interest in AMATYC (American Mathematics Association of Two Year Colleges) in research in mathematics education, and a group has formed within AMATYC to pursue and promote research at the community college level.

AR: You've already given a partial answer to my next question, which is: What kinds of positions do graduates of your Ph.D. program pursue? You mention that some are looking for mathematics education positions in mathematics departments. What are some other typical landing spots?

MS: Our Ph.D. graduates also search for positions within departments of Curriculum & Instruction in schools of Education, or post doc positions working on research grants through research institutes or research centers though these have been rather rare in mathematics education. Those students who come to us from Community Colleges tend to want to return to teaching at the Community College level, but to also have part of their FTE be devoted to research or curriculum development at a Community College.

AR: How big a role does the teaching and learning of statistics play in your program? Do all students study some aspect of statistical reasoning? Do most study statistics to some extent? Have many of your students specialized in statistics education, and what topics have they investigated?

MS: Since the launching of our doctorate in mathematics education, research on the teaching and learning of statistics has played an integral part of our program. Doctoral seminars that focus on research in statistics education have been offered frequently over the last fifteen years. Students in our program take graduate level course work in mathematics and statistics along with their mathematics education work, and we have encouraged our doctoral students to take graduate level statistics courses as part of their program. Those students who are researching statistics education have even added a Master's degree in statistics to their program while they are working on their doctorate in mathematics education. Within the last six years or so we have had three graduates of our program who specialized in statistics education. The topics they investigated were primarily about the statistical thinking and beliefs about statistics of various levels of tertiary students, including prospective elementary teachers, mathematics and engineering upper division majors, and statistics teaching assistants. Another doctoral student in our program is currently just beginning to develop a research proposal in statistics education.

AR: This sounds terrific. Would you say that your program is fairly typical? I'm wondering about how much study of statistics and statistics education is involved with most Mathematics Education programs?

MS: I suspect that our mathematics education doctoral program is rather atypical in the amount of statistics education research work that has been included for our students, and probably also atypical in the percentage of students who have chosen statistics education as their own field of study. As you know, the University of Minnesota has a doctoral program in Statistics Education, currently the only such program in the U.S. There are other universities that have been discussing the possibility of creating a doctoral program in statistics education, too. Discussions have also been going on about developing shared courses in statistics education among several universities. That said, the field of statistics education has been growing a lot over the past decade in the United States, and students from many different universities across the country are pursuing research in statistics education.

Development of Statistics Education

AR: Statistics education is a much newer field than mathematics education. Would you say that statistics education is still in its infancy, or would you use a different descriptor for where statistics education is in its development? What are your thoughts on the growth thus far of the field of statistics education, and on the prospect for continuing growth?

MS: Let me start with an analogy to the historical development in mathematics education. In the late 1960's and early 1970's, the idea of conducting research in mathematics education, studying the teaching and learning of mathematics in a systematic and rigorous way, was just beginning to blossom. Several research journals in mathematics education were established around that time. *Educational Studies in Mathematics* (ESM) and *Journal for Research in Mathematics Education* (JRME) were among the first. *JRME* was launched in 1970, *ESM* a bit before. The field of mathematics education has grown tremendously over the past 40 years. In the mid 1970's when I was a doctoral student, there were hardly any people in the world concentrating on research in statistics education, and statistics education was not recognized as a separate discipline. If you were working in research on the teaching and learning of probability and statistics, that was considered to be a branch of mathematics education, and a very tiny branch at that. The seed for statistics education as a field was probably planted at the very first ICOTS meeting in Sheffield, England, in 1982. There was actually a session at ICOTS 1 devoted to research in probability and statistics. I was fortunate enough to be invited to attend ICOTS 1 by the program chair, Lennart Råde, and to present at this session. There were six of us who presented in Sheffield, and for me that was the beginning of statistics education as a recognized field of study. It was exciting that there were other scholars around the world interested in studying statistics education. Over the next decade statistics education began to grow rapidly in a number of countries, particularly in Germany, Israel, Australia, and England—and eventually more in the U.S. For the past twenty years, statistics education has grown into a discipline of its own. Research journals such as *Statistics Education Research Journal* and *Journal of Statistics Education* have been established and are valued outlets for research in statistics education. The ICOTS conferences now have many more sessions devoted to research in statistics education. For example, there currently are seven research sessions planned just within the Topic of Statistics Education at the School Level for the ICOTS 9 conference in the summer of 2014. The international working group SRTL meets every two years to share and brainstorm on a particular topic in research in statistics education. This past July there were two Topic Working Groups, one in statistics and one in probability, at the ICME 12 Congress in Korea. The attendance in the statistics topic was stunning to me. There were six of us interested in research in statistics education at ICOTS I. There were over fifty attendees within the statistics topic at ICME, and nearly as many in the probability topic. These were researchers and doctoral students from countries all over the world. So, when you ask about the prospect for continuing growth and interest in statistics education, the sky's the limit. Interest is booming, and the future of statistics education is very exciting indeed.

AR: This is very interesting to hear about the development of statistics education compares with the development of mathematics education. Your response brings many follow-up questions to my mind, but let me start with: What was the first ICOTS like? I can imagine that it was very exciting to be part of the first-ever international gathering focused on the teaching of statistics.

Was there a palpable sense of excitement? Do you think anyone could have guessed that statistics education would grow in appeal so much in the next 30 years? Oh, and I also have to ask: Have you attended all eight ICOTS conferences thus far?

MS: There were around 300 delegates to the very first ICOTS in Sheffield. I remember very well Lennart's address, and how he hoped this would be the start of ongoing international meetings about statistics education. The excitement for all of us, especially those of us like me who were young and just out a few years, was to meet others who were interested in statistics education. I was pretty amazed that people in other countries knew about my work, had read it, and had questions on it for me. There was an instantaneous sense of collegiality that I had not experienced around research on probability and statistics education previously. Here was a new community to 'belong to.' I met Heinz Steinbring, Manfred Borovcnik, Ruma Falk, and David Green—they were among the others who also presented in that first research session at an ICOTS. I have corresponded with them all throughout the years, sharing papers and answering questions, and this was way before there was e-mail or anything like the social networking of today. Perhaps my fondest memory of ICOTS 1 occurred at the banquet on the last night of the conference. We were all seated at these very long tables. It was quite elegant (English, you know). An older gentlemen with a sparkle in his eyes was seated across from me, and when we all began to introduce ourselves among those nearby, he leaned across the table and said "Professor Shaughnessy, when are you going to give up your recent interest in geometry and do some more work in probability?" It was Efraim Fischbein, one of the founders of research into children's thinking about probability, with his theory of primary and secondary intuitions. Professor Fischbein was also one of the founders of PME—the International Group for Psychology and Mathematics Education. I had used his research as a basis for some of the points I was making in my own doctoral research. The fact that he took the time to talk to me, and was truly interested in what I had done, and encouraged me to do some more, I've never forgotten his kindness, and I have tried throughout my career to talk and listen to young graduate students in mathematics and statistics education as he did with me, and follow his great example.

I don't think any of us in attendance ever dreamed that statistics education would grow as much as it has over the next 30 years. We all very much were hoping to promote the importance of students taking more statistics in the schools, and in colleges and universities. And there was some hope that there would be a next ICOTS (there was, in Vancouver, BC). That ICOTS would become established, and become such a great conference—now we are looking toward ICOTS 9—we didn't anticipate that. And no, I haven't been able to attend all eight ICOTS, but I do have 5 of them notched into my resume.

AR: That must have been very exciting to be part of the first ICOTS. My introduction to ICOTS occurred in Marrakech in 1994 with ICOTS4. I have not missed any since, so I'm tied with your total of 5 ICOTS attended. Thanks especially for your great story about Professor Fischbein. I have to ask: For how long did *you continue to pursue your interest in geometry?*

MS: I still do. I have always been interested in how students think about geometry, ever since I had an opportunity many years ago to work on an NSF Research grant based on the van Hiele levels of reasoning in geometry. Pierre and Dina van Hiele were teachers and researchers in the Netherlands who developed their theory of 'levels of geometric thinking' in the late 1960's and early 1970's. I continued to develop mathematics courses for pre-service elementary, middle, and secondary mathematics teachers in geometry throughout my career, and recently I've made a number of presentations on Reasoning and Sense Making in geometry, with connections to the Common Core Standards for Mathematical Practice. (I've also made presentations on Reasoning and Sense Making in statistics, by the way). So although I did return to research and development in probability and statistics, I have never given up on my geometry interest. I think Professor Fischbein would be at peace with this outcome.

AR: Yes, indeed. I'm glad that your interests in geometry have not precluded your devoting substantial attention to probability and statistics. Back to statistics education and mathematics education: Can you think of some lessons learned in the development of mathematics education that could benefit statistics education as it grows? More specifically, have there been any growing pains or wrong turns in mathematics education that we in statistics education could learn from?

MS: As more graduate students pursue statistics education and programs are formed around Ph.D.'s in statistics education, those programs can learn some things from doctoral programs in mathematics education. Research methodologies in education are broad and varied, and not all research involves purely quantitative methods. For example, research literature and methodologies in philosophy and psychology of mathematics education—epistemological theories and learning theories in particular—are just as important for the grounding and background of statistics educators as they are for mathematics educators. So, one lesson in the historical development of mathematics education for statistics education is to include research from areas of the social sciences and other areas of education, and to form teams of researchers from multiple disciplines. A growing pain that mathematics education experienced was the push back that occurred during the math wars from some entrenched perspectives that led to endangering the possibility of any reasonable dialogue or discussion about differences in approaches to the teaching of mathematics. Rhetoric and opinion trumped thoughtful interaction and empirical research results. I do not foresee that 'wrong turn' occurring in statistics education. Statistics educators have been including statisticians throughout the development of statistics education as a discipline, and so far there has been a willingness to listen and try approaches to teaching statistics throughout the statistics and statistics education community.

Preparing Teachers of Statistics

AR: I want to turn to the issue of preparing future teachers of statistics. How does Portland State prepare students who plan to become mathematics teachers and therefore are likely to be teaching some statistics as well?

MS: There are special statistics courses at Portland State in our programs for both secondary mathematics and middle school mathematics teachers. Prospective Secondary teachers are required in their program to take a "Statistics for Secondary Teachers" course which we developed in our department. The course is also required of students in our MST program that is predominantly enrolled with current high school mathematics teachers. We have a separate Statistics for Middle School Teachers course as part of our Middle School Mathematics Graduate Certificate Program. The approach in both these courses follows recommendations from the

NCTM Standards and from the GAISE report. We incorporate readings from research on how students learn statistics and conceptual difficulties students have with statistics. There is an exploratory data analysis component; use of technological tools for data analysis, simulations, informal inference (such as *Fathom*, *Tinkerplots*, TI calculator data analysis tools, the *Core-Tools* data package available on NCTM's website); readings from the NCTM journals, SERJ, JSE and other sources on the teaching and learning of statistics. We try to explicitly model the teaching in these courses the way that we believe middle school and high school students should encounter statistics. The teachers in our classes even work through some problems similar to those found in middle school or high school curriculum materials—thus we try to incorporate a pedagogical content knowledge piece into these courses, as well as boosting teachers' statistical competence and confidence to teach statistics.

AR: These sound like great courses to prepare future teachers. Two quick follow-ups: Do you have a sense for whether Portland State is unusual in requiring such courses of prospective mathematics teachers? And would your pre-service teachers take this course in addition to more content-based courses in statistics?

MS: Some students will take additional statistics courses along with this special course taught by a statistics educator, but they are not required to do so within their program. We feel fortunate to have these special courses in our department, but of course this one course is not enough, it would be better if they took another statistics course that builds on this one. Across the country I do believe Portland State is a bit unusual in requiring these special statistics courses for prospective secondary and middle school teachers. I am aware of several other universities that have such a course for middle school teachers.

AR: What do you think of the Mathematical Education of Teachers report put forth by the Conference Board of the Mathematical Sciences (CBMS) in 2001 and updated in 2012? Did you have a hand in developing the recommendations in those reports? What do you think of the recommendations with regard to preparation for teaching statistics and probability? Has your department's program been influenced by these reports?

MS: The recent MET II update on the Mathematical Education of Teachers (published by CBMS, 2012) contains strong recommendations for the mathematical and statistical content in the preparation of future teachers, and also contains recommendations that address needed pedagogical content knowledge for future teachers of mathematics and statistics, grades K – 12. For middle school teachers, 24 content hours are recommended including a special course in statistics for middle school teachers. MET II recommends that secondary teachers be required to major in mathematics, or to take coursework equivalent to the requirements for a mathematics major, including a two course sequence of statistics for secondary teachers. The MET I report recommended a single statistics course, the MET II authors realize that one course is completely insufficient in today's world of statistical information and statistical reasoning. The MET II report provides excellent recommendations for the statistical preparation of middle and secondary teachers, and in making them the MET II authors are being farsighted for the statistical needs of tomorrow's students. Unfortunately, the statistics recommendations for the preparation of elementary teachers are not as strong, since they are embedded within a broad strand called "Measurement and Data," a progression that is oriented much more towards measurement (linear, area, and volume measurement) than towards statistics. The MET II recommendations for gathering and displaying measurement data have more to do with representing fractions and decimals on the number line than they do with reasoning about distributions of data. This approach is not surprising, given the relative absence of a real statistics progression in grades K – 5 in the Common Core State Standards. I was not involved in the actual writing the MET II document, but I did have several opportunities to provide input and review for MET II on the statistics recommendations for the preparation of future teachers. Our department has long been influenced first by the recommendations of the old CUPM Committee of the *Mathematical Association of America* (Committee on Undergraduate Preparation in Mathematics), and more recently by the recommendations from the subsequent MET I and MET II reports.

AR: If I remember correctly, the MET I and MET II reports also do a good job of emphasizing that the statistics courses taken by prospective teachers should not be a standard sequence in probability and mathematical statistics. I want to ask about a phrase that you used: pedagogical content knowledge. Can you explain this term for the benefit of readers who are not familiar with it, and perhaps provide an example of a particular piece of pedagogical content knowledge that future (and current!) teachers can benefit from learning?

MS: You are absolutely right that MET II emphasizes that courses in statistics for teachers should not be the ‘standard’ sequence in mathematical statistics. A deep conceptual understanding of the major ideas in statistics is crucial for teachers. Among the most important concepts for teachers I would include: aspects of distributions of data (center, shape, and variation); probability as long range relative frequency, and the power of simulations to estimate probabilities of events; sampling, sampling distributions, and informal inference via simulations and re-randomization techniques; and, association—both for categorical (contingency tables, row-column proportion comparisons) and numerical variables (Quad Difference, median-median fit line, least squares lines and other functions, residuals, etc.). Teachers not only need to understand these big ideas, they need knowledge of their students, knowledge of good teaching (in general), and knowledge of the issues in probability and statistics that students will have difficulty with, knowledge about the intuitive or transitional conceptions that students will exhibit and how to build on students’ transitional or newly formed and somewhat fragile conceptions. Pedagogical Content Knowledge is a construct that was first mentioned in the literature by Lee Shulman in the 1970’s. For example, students may have difficulty with interpreting boxplots—in part because the actual data is masked in a box-plot as it is a summary of important measures in the data. We don’t really know the actual underlying distribution of data when we look at a box-plot. One pedagogical content move would be to superimpose the box-plot over the top of a dot plot of the same data—thus providing the actual raw distribution along with the summary of critical values (min, median, max, outliers, etc.). Pedagogical content knowledge involves planning based on what students know, and what they don’t know. A teacher who is growing their pedagogical content knowledge is always listening carefully to their students’ reasoning and explanations for their thinking.

National Council of Teachers of Mathematics

AR: Very nice, I like that example of PCK very much. (I’m trying to impress you and the readers *by using the acronym of pedagogical content knowledge!) You mentioned the Common Core State Standards in your answer a question or two back, and I certainly want to ask about your impression of those standards. But that topic is closely related to your having recently completed a term as President of NCTM, the National Council for Teachers of Mathematics, and I want to ask questions about that experience also. Let's start here: For the benefit of* JSE *readers who are not very familiar with NCTM, please summarize what this organization is and does, and also let us know how your involvement with NCTM began.*

MS: Ah, this is a question that I could go on about for an entire interview just on NCTM. The National Council of Teachers of Mathematics is the largest professional organization of mathematics teachers in the world. Established in 1920, the mission of the Council is to be the public voice of mathematics education, supporting teachers to ensure equitable mathematics learning of the highest quality for all students through vision, leadership, professional development, and research. The Council's vision is to create a world where everyone is enthused about mathematics, sees the value and beauty of mathematics, and is empowered by the opportunities mathematics affords. NCTM has nearly 90,000 individual and institutional members from all over the world, although primarily from the U.S. and Canada. NCTM publishes journals, books, and electronic resources for mathematics teachers and teacher educators, including *Journal for Research in Mathematics Education (JRME), The Mathematics Teacher, Mathematics Teaching in the Middle School, Teaching Children Mathematics,* and *Mathematics Teacher Educator.* The Council puts on regional conferences and an annual conference for mathematics teachers K – College, conducts frequent webinars focused on particular issues for its members, and creates Professional Development Institutes, both during the summer and during the academic year in order to bring particular grade bands of teachers (3 – 5, 6 – 8, etc.) together to work on deepening their content and pedagogical content knowledge in particular areas of the mathematics curriculum.

I joined NCTM in 1973 when I was a graduate student. A reader's digest version of my work with NCTM would go like this: I got actively involved with NCTM in the 1980's, served on the editorial panel of *JRME*, several terms on the Joint ASA/NCTM Committee, a member of a number of editorial panels that wrote books and resources for teachers (mostly on probability and statistics in my case), was elected to the Board of Directors of NCTM and served from 2001 – 2004, and I now am completing my term of service as President of NCTM (2009 – 2013) while in my final year as immediate Past President. The four-year term begins with a year as President-Elect and then a two-year stint as President.

AR: Can you describe your experience as NCTM President for us? No, wait, that's too vague. How about describing for us one aspect of the position that you found particularly interesting, or that took a considerable amount of time, or that led to an impact that you're particularly pleased with. (Perhaps you can think of one example that meets all three of those conditions!)

MS: My time as NCTM President has been quite a ride—a great honor for me, and a challenging learning experience. There are a lot of things that come to mind in responding to this question, but for now I'll pick two.

Traveling about the country to various state and affiliate conferences was one thing that took a tremendous amount of time (especially for me living in Oregon), but it also has been one of the most gratifying parts of my presidency. There are so many terrific, committed mathematics teachers doing great things in their states, districts, and schools around the country. The teaching profession, and in particular mathematics, has gotten hammered so often in the media over the past decade, that it is truly been uplifting for me to meet so many great teachers and leaders from all corners of our nation. I have met many teachers who continue to work hard to get their students to enjoy mathematics and be successful with math, despite all the negativity that surrounds them. Furthermore there continue to be some wonderful young people going into the profession, at perhaps the most challenging time for schools and teachers, as they are faced with evaluation tied to test scores, closing unsuccessful schools, and complaints that the U.S. is not #1 on international mathematics assessments.

As for something that I feel has had an impact during my Presidency, I've been pleased that NCTM has had a major initiative on Reasoning and Sense Making in Mathematics including publishing a series especially for secondary teachers that provides extended concrete examples of reasoning and sense-making approaches in classrooms for algebra, statistics, geometry, and teaching mathematics with today's technology. The Reasoning and Sense Making resources for NCTM provide excellent illustrations of the Standards for Mathematical Practice in the new Common Core Standards for Mathematics. The Council has also launched a new series of professional development Institutes for teachers in all grade bands (K – 2, 3 – 5, 6 – 8, 9 – 12) that have focused reasoning and sense making as support for teachers who are implementing the new Common Core standards.

AR: I'm sure that we could devote an entire interview to discussion your term as NCTM President, but I do want to be mindful about not taking up too much of your time. I can't resist following up on both of these things that you've mentioned. You referred to the negative media attention that math teachers have received recently. My sense is that being President of NCTM is a much more public and political position than having a similar leadership role in an association such as ASA or MAA. Can you comment a bit on the public and political aspects of your role as NCTM President? (As always, of course, please correct me if I'm conveying a mistaken impression again!)

MS: The NCTM President is the spokesperson for the Council, and as such, he/she responds to frequent questions from the media. This includes reporters from large city newspapers or journals like *Education Week* who are writing stories on a variety of issues that a mathematics teacher organization might (or might not!) have a position on. I've been asked questions by reporters on topics such as why are state math test scores not increasing, recommendations for mathematics curricula, attitudes toward mathematics, math anxiety, how can parents help their students with homework, what does NCTM think about the Common Core, what is going on with the new assessments being developed by the Assessment Consortia, what does NCTM think about the recent Common Core Guidelines for Publishers, etc.

Also, during my Presidency NCTM continued to increase our interaction with the Department of Education. There is a line of communication open with the Department now for the first time in a number of years. The Department has asked us to react to some things they have been drafting, and we have asked them to share information with teachers at our conferences. As a result, Secretary of Education Arnie Duncan has spoken at the last two NCTM annual conferences, and fielded questions from the floor from our teachers on topics like the reauthorization of the Elementary and Secondary Education act, tying the evaluation of teachers to student test scores, and the need for increased support for teachers, districts, and states as they implement the Common Core State Standards.

So, yes, the leadership role of the NCTM President if definitely very public and very political, and it has been becoming more so over the last decade. Of course, when the President responds to reporters and interacts with the U.S. government, he/she also gets an earful from members. Our membership does not suffer from a dearth of strong opinion on just about any topic you can imagine. The Council has had to work hard over the past 10-12 years to get recognized as an organization that should, that must, be at the table on issues of national policy involving the mathematical education of our K – 12 students, and of the mathematical education of the teachers who work every day with the students in schools in our nation. Several NCTM staffers are dedicated to public relations and advocacy in the Beltway area.

This describes just a few of the public and politic role occurrences during my Presidency. One enters this fray because of a dedication to mathematics education, teachers, and their students. But it comes with all kinds of baggage, including a huge PR and political piece. There is a steep learning curve, and just about the time you have a fairly good handle on this stuff, your time is up as President. I wouldn't say I loved it, but I learned that these political situations can provide good opportunities for the Council to get our message out there, too.

Common Core State Standards

AR: Yes, it's great that NCTM has gotten its message out and is a respected voice at the public policy table. I have to ask: what does *NCTM think about the Common Core State Standards (CCSS)? And equally important, what do* you *think of the CCSS?*

MS: Ah, somehow I suspected that might be your next question, given my response to the last question. NCTM sees the Common Core standards as an evolutionary step based on NCTM's own history of writing standards first in 1989, and then again with *Principles and Standards* in 2000. Ten years ago, neither NCTM nor the nation was ready to write grade-by-grade level standards. You will recall that NCTM's standards are written by grade band. The political climate now has changed as the states and governors have led the development and adoption of the Common Core Standards. NCTM views the Common Core standards as an unprecedented opportunity for states to establish common mathematics goals for K – 12 students and to agree to a common mathematics assessment of students across states. Although most states implemented the NCTM standards, there were big differences in how they implemented them, how they assessed them, and whether they actually implemented and assessed NCTM's Process Standards. The Common Core includes not only mathematical content, but also the Standards for Mathematical Practice are very closely aligned with NCTM's Process Standards. The opportunity this time around to actually implement the recommendations for the teaching and learning of mathematics as posed in our Process Standards is one great hope that NCTM has for the Common Core implementation.

You ask what I think of the Common Core standards. As NCTM President I was the public voice for the council on the standards, and in that role I emphasized the potential opportunities that these new standards provide for our nation, schools, teachers, and students. Of course, the flip side of opportunities is the challenges side. A great deal of professional development for our teachers is needed for us to be successful at implementing the Common Core standards. Many of our teachers are not used to teaching mathematics in a way that will foster the Mathematical Practice standards in their students. There is insufficient funding available to address the magnitude and scope of the need for professional development. It will be a rocky first few years under these new standards, and we will all need to persist in implementing them and stay the course in the face of push back. The first few rounds of the assessment will likely reveal rather dismal results as the bar has been set higher for many states and districts in some of the content areas. This is particularly true of statistics, as there is more statistics in grades 6-11 in the Common Core standards than there had previously been in most of our state standards. Our teaching force is largely unprepared to teach the statistics in the Common Core. On top of that, the Common Core does not have a gradual ramp up in K – 5 to the sudden emphasis on probability and statistics that appears in grades 6 & 7. From my point of view, this is one of the biggest mistakes in the Common Core, and I trust that over time there will be some adjustments made to the omission of statistical concepts in the elementary grades. One of the mantras of the Common Core has been "fewer" standards. Unfortunately in the case of statistics, fewer became none in K – 5.

AR: There is so much statistics in grades 6-11 of the Common Core standards that some college faculty are wondering if we should begin now to re-think what we teach in our undergraduate "Stat 101" courses. Do you agree that the Common Core has considerable overlap with Stat 101, and should we begin to re-think what we teach in Stat 101 in preparation for graduates of the Common Core curriculum?

MS: While there is some overlap with "Stat 101" in what is proposed in the grade 9 – 11 statistics content in the Common Core, I wouldn't assume that just because it is there that it will suddenly be well taught, or well learned. As I mentioned before, we have an immense professional development hill to climb in order to successfully implement parts of the Common Core, and I think that will be particularly the case for the statistics component. After a few years it should indeed be possible for college level statistics instructors to build upon the statistics that secondary students will have learned prior to college. Hopefully we will be able to do a better job with the statistics transition from high school to college than we have done with say, algebra, prior to the Common Core. I'm very much hoping that the Common Core will help to reduce the remedial gap that occurs in algebra when students move from high school to college. Right now we have so many types and brands of algebra throughout the high-school-to-college trajectory. Algebra I, Algebra II, Pre-calculus, Elementary Algebra, Intermediate Algebra, College Algebra, more Pre-Calculus—this is the track that I refer to as "death by algebra." I *really* hope that we do not fall into this awful trap with statistics. We need a solid high school experience in statistics for our students, followed by a thoughtful transition to college level statistics, without trying to remediate everyone for everything. Let's not do with statistics what has been done with algebra over the past forty years in our colleges, universities, and high schools.

AR: One way to help climb the professional development hill that you mention is by developing helpful resources for teachers. You mentioned the NCTM series on Reasoning and Sense Making in Mathematics, and I know that this includes a volume for Probability and Statistics that you co-authored with Beth Chance and Henry Kranendonk. Can you tell us about the goals and content of this book?

MS: I'd like to begin with a short overview of the NCTM Reasoning and Sense Making Initiative itself. The goal of this initiative is to repurpose and re-emphasize the NCTM Process Standards that appeared first in *Principles and Standards for School Mathematics* (*PSSM*, 2000), with a focus on high school mathematics since *Curriculum Focal Points* (2007) had recently come out from NCTM for Pre K – 8 mathematics teachers. Starting in 2009 and continuing to 2012, NCTM published a series of 6 books in the Reasoning and Sense Making series, one of which was the volume for Probability and Statistics. The main messages in this recently published series are that the teaching of mathematics must shift from a perspective of delivering information to a process of facilitating student discourse, student reasoning, students engaged in sense making (context plays a big role here), and students sharing problem solving and communicating their thinking. Actually *PSSM* advocated these same messages, but a decade after *PSSM* too few of our secondary mathematics classrooms are being conducted in this way.

The Probability and Statistics volume (Shaughnessy et al., 2009) is one of three content based books in the series (the other two are Geometry and Algebra) in which we provide deep discussions of a few rich statistics tasks. At times these discussion can take the form of "conversations" with instructors who are intent on developing a reasoning and sense making approach in their classrooms. These conversations include a) the task or investigation itself along with implementation strategies for the task; b) examples of student reasoning and student responses that we have encountered when we have used these statistical tasks ourselves, and c) discussion with notes to the teacher explaining why we do things in certain ways, providing transparency about the task itself and about the reasons we ask of students certain questions during the task, as well as suggestions for next steps for teachers when they encounter certain types of responses from students.

The key statistical elements we pursue in this book include analyzing data, modeling distributions, connecting probability and statistics, and interpreting designed statistical studies. Along with these key elements we provide a blueprint for "habits of mind in statistical reasoning and sense making in Statistics and Probability." Some examples of these habits of mind include analyzing and explaining variation; choosing and critiquing data collection strategies; comparing various graphical and numerical representations of the data; and determining whether a conclusion based on data is indeed plausible. (Altogether we offer 25 of these habits of mind for statistical reasoning). The book then follows with 6 detailed investigations, each in a separate chapter, each illustrating a subset of the statistical habits of mind with an approach based in student reasoning and sense making. Our NCTM Reasoning and Sense Making Initiative has even more of an urgency about it now that the Common Core State Standards have appeared and include the Standards for Mathematical Practice that are very much in tune with NCTM's Reasoning and Sense Making Initiative.

AR: I also want to ask about another NCTM book that you wrote with Beth Chance – Statistical Questions from the Classroom*. What motivated that project, and what are its goals?*

MS: NCTM books have a variety of different birthing paths. Sometimes potential authors will send in an idea and a bit of manuscript for consideration. Sometimes the NCTM Board of Directors starts a big writing project, such as *Principles and Standards for School Mathematics,* or the *Navigations* series. Sometimes the Educational Materials Committee of NCTM assembles an editorial panel to draft and then write a book in an area of perceived need. It was this latter path that led to *Statistical Questions from the Classroom*. I received a letter from then NCTM President Glenda Lappan asking if I would be willing to chair a panel of potential authors to draft a collection of short chapters that addressed questions that often pop up from students in statistics classrooms, questions such as: Why do we square those deviations? and, Why do we divide by (n-1) instead of n? The book also was asked to provide examples and explanatory detail for some of the more difficult concepts that students encounter in an intro stat course, such as: What is margin of error? What is a p-value? What is independence? etc. NCTM assembled a panel of teachers and statistics educators to write some draft pieces for the book, which we did, and then the idea was that these folks also were actually to write the book, too. However, somehow that second part—actually writing the book—wasn't quite communicated to my panel. As chair I asked NCTM if I could bring in Beth to write the book with me, so that we could actually complete the charge that NCTM had given us. You have had considerable experience writing with Beth, so you well know that she is a great colleague to work with and what a terrific co-author she is. I know that if Beth agrees to do something, it gets done, so I was very lucky to convince Beth to write *Statistical Questions* with me. I really like that little book, and I've had many high school statistics teachers come up to me at NCTM conferences and tell me that they like it, too, and have found it quite helpful. Thanks again, Beth!

AR: I'd like to go to back to the Common Core for a moment. I've heard some express concern that the Common Core might be a passing fad. What do you think are the prospects that Common Core is here to stay and will have the long-term impact that its proponents would like?

MS: Over two years ago the Common Core Standards in Mathematics were adopted by 45 of our states, as well as some of our U.S. territories. This was a state-by-state decision made by governors, state legislatures, and state chief education officers. This is the first time in the history of our nation that this kind of co-operative state decision about educational standards has occurred. There is unprecedented political clout behind this decision, and that makes it quite different than previous individual state standards, which may, or may not, have faithfully implemented the NCTM *Principles and Standards for School Mathematics* a decade ago. At the same time, two assessment consortia, the Smarter Balanced Assessment Consortia (SBAC) and the Program for the Assessment of Readiness for College and Career (PARCC) have been funded to develop *common* (emphasis here!) mathematics assessments across the states, another first in our history. About half the states are in each of the two assessment consortia. The assessment work is making a lot of progress. Sample items are being released, and this spring large-scale piloting of items and forms will begin to take place around the nation. Individual states have been working hard to help districts, schools, and teachers with implementation and professional development for the common core. In some cases, groups of states are working together, and all states are sharing what they are doing or trying through the organization of State

Mathematics Supervisors (ASSM). I would say that the Common Core is as far from being a passing fad as any educational movement I have ever witnessed in this country.

There are several potential benefits of the Common Core that could improve the mathematics and statistics education of our students, and because of them I hope very much that the Common Core has a long-term ride, long enough to give it a really good shot, and to make changes and adjustments to it in the future when we locate the bugs and missteps in this first version. We have enormous problems in our country with inequities in opportunity and access to good mathematics education in our schools, across states, within states, and even within cities in our states. The fact that 45 states have agreed to these standards, that there will be common assessments, and that the assessments will include the Standards for Mathematical Practice (similar to the NCTM process standards), gives me hope that in the long run we might be able to improve our students' mathematics experience in many of our schools beyond what it is now.

All that said, it is going to take considerable willpower on the part of state leaders, assessment developers, mathematics education leaders, and our teachers themselves, to stay the course with the common core, and give it a really good chance. When the results of the first run of the assessments are released sometime in 2015, there is no doubt that the nation will get a rather dismal report card. The nation has a very long way to go to hit the mark that these standards have set, and just because they have been adopted and we've had a few years to begin implementing them doesn't mean that our students are going to make a good showing on that first assessment run. We will establish 'where we are' as a nation with regard to the Common Core, and then we'll have something to build on and improve over the next five to ten years. The Common Core absolutely has to be a long-term event, otherwise, why even bother in the first place. The fact that there is the will power in our country to try this gives me hope. And yes, of course, there are many challenges and some potential problems with the Common Core, too, but many of those problems and challenges are already there anyway, prior to the Common Core. If ever our nation needed staying power on an educational movement, this is the time.

Pop Quiz

AR: Thanks very much for that rousing call for action and perseverance. I'm very encouraged that you think the Common Core has great potential for strong impact. Now let's move to what I call the "pop quiz" part of the interview, where I'll ask very specific questions and will ask you to give very brief answers, no more than 3 sentences. First, what are some of your hobbies outside of statistics education?

MS: Thank goodness! I thought you were going to ask me to critique a statistical design and suggest improvements!

I've been a runner for over 35 years, since when I first came to Oregon State. I ran track and cross-country in high school, but then got away from it during my college and graduate school years. Oregon is arguably the best running state in the nation, one of the few states where you might be considered strange if you *don't* run (just kidding). Other hobbies include music, and gardening. I've been singing in male choral groups for about fifteen years now, and I am currently a member of *Satori*, a men's choir in Portland whose mission is men singing peace.

Great group of guys, we sing an eclectic collection of music (pop, jazz, classical, show tunes, folk) with at least one concert a year dedicated to peace in the world. The gardening, well, since it rains so much in Oregon, the best way to deal with that is to join in, and plant what you want to see out your windows. Otherwise the state will produce what it wants and you will be overwhelmed by gangly trees, vines, and weeds. Something is always growing here.

AR: What fun – I did not know any of those things about you. Next: What are some books that you've enjoyed reading in the past year?

MS: I've been on quite a Teddy Roosevelt read over the past several years while I was NCTM President. *Wilderness Warrior* by Douglas Brinkley, *River of Doubt* by Candice Millard, and *The Big Burn* by Timothy Egan are three of my recent favorites. Teddy is the President who set aside most of our National Parks, National Monuments, and National Wildlife Refuges. He really was amazing. The people loved him. The mining and railroad interests hated him. Two other reads within the last year are *This is your Brain on Music* by Daniel Levitin, and *Unbroken* by Laura Hillenbrand. Levitin was a rock musician who became a neuroscientist and towards the end of the book he gets into some interesting research being done on brain activity and music. *Unbroken* is the story of a great young runner from California in the era just before World War II when the 4:00 minute mile was being seriously challenged around the world. Louie Zamperini qualified for the 1936 Olympics in Berlin, and a few years later joined the Air Force. His war experience is one of the most amazing survival stories ever. Interested readers might recognize Hillenbrand as the author of *Seabiscuit,* too. On the fiction side, I've just finished the monumental tome that is the five-book series *A Tale of Fire and Ice,* of which *Game of Thrones* is the first volume. George Martin started writing this saga because he said that Hollywood overly limited the character set and the details he wanted to include in movie scripts that he has written. There is a sixth book on the way. I'm afraid that Martin will not come to closure in this tale, it just seems to keep expanding and unraveling. I now understand what the Hollywood producers were saying.

AR: Please tell us about your family.

MS: My wife Joan and I met many years ago at a small college in upstate New York, Le Moyne College. We will celebrate our 43rd wedding anniversary in June. Joan has worked many years in education, too, on a number of projects. She worked for twenty years at the Northwest Regional Educational Lab in Portland. We have two daughters and three grandchildren. Our older daughter lives in Seattle, with a daughter age 8 and a son age 5. Our younger daughter lives in Bariloche, Argentina, and has a daughter age 1.5. Daughter in Seattle works with vets from WWII, Korea, Vietnam, and current returning vets from Afghanistan at the VA Hospital in Seattle. Younger daughter is a translator, from Spanish to English, and she can do that work anywhere in the world. Having part of our family living in Argentina is fallout from twenty years ago when I had a sabbatical in Spain. Somehow ten year olds decide that they can go and live anywhere in the world after such an experience. And then they do.

AR: Wow, that's terrific! I know that you've been to Argentina to visit, because that's where you were when I invited you to be interviewed. Speaking of travel, you've done a lot of that as

NCTM President. How extensive has that travel been? And where is the favorite place that you have visited in the world?

MS: It feels like half of my life the past four years has been on airplanes. Yes, travel for NCTM has been very extensive, both for NCTM Board and Committee meetings and to speak at meetings and conferences. Your question made me wonder just how many places I've been during my presidency so I checked and discovered that I have spoken at 30 different state Councils of Teachers of Mathematics meetings during my term (Wisconsin Teachers of Mathematics, New Jersey, Idaho, North Dakota, New Hampshire, New York, California, Minnesota … you get the picture). I also traveled and spoke at international meetings in Norway, Sweden, Slovenia, Korea, Canada, and Australia.

The question about favorite place I've visited depends a bit on the criteria. My favorite professional meeting was the combined MERGA-AAMT meeting in Alice Springs, Australia. This meeting brought together both the research community, Math Education Research Group of Australasia (MERGA) and the Australian Association of Mathematics Teachers (AAMT) for a combined three-day meeting. Sessions had three presentations each from teachers and from researchers, for example two of the three half hour presentations might be from researchers, the other from a teacher, or vice-versa. It was an extraordinary and exemplary effort to link research and practice.

The meeting in Trondheim, Norway brought together mathematics teachers of all levels from all over Norway, Sweden, and Finland. It was my first venture near the Arctic Circle in winter. The teachers at that conference were so welcoming, wonderful people who made me feel I was one of them. That's one of my fondest memories traveling.

I suppose that the ICOTS conference in Ljubljana, Slovenia was my favorite international place because it was so surprisingly delightful there—the country, the people, their history. We visited the area where my wife's grandmother lived before her people, called the Gotcheers, were driven out by developments in the Austro-Hungarian Empire prior to World War I. I believe you were at that ICOTS conference, too, so you know what I'm talking about, that Slovenia is a great place to visit.

The bottom line for my favorite place though really was whatever state conference for mathematics teachers I was attending at the moment. The enthusiasm for mathematics and the commitment to their students that I saw over and over among the teachers at these conferences really made me proud to be President of NCTM.

AR: My next question is a fanciful one. Suppose that I offer you dinner for four to discuss any topics of your choice regarding statistics education. Who would you choose for your three dinner companions? Oh, and while I'm being fanciful, I'll also ask you to select any location in the world for hosting this dinner.

MS: The difficulty with this question is that I can only have three dinner companions. Most dinners I've had with statistics educators involve 6 to 8 dinner companions. So, my apologies to my other Stat Ed friends who won't be able to get reservations with us for this one.

Some of my best dinner encounters with Stat Ed people have been with Jane Watson, Cliff Konold, and Joan Garfield. It's rare that I've had all three of them at one time, and if so, certainly not just the four of us. It would be a dangerous dinner on two accounts. First, with both Joan and I there, we'd make some excellent, therefore rather expensive, wine selections. Second, these three folks are always hatching the 'next big thing' for statistics education. So the fall out from the dinner would likely involve quite a bit of work with one or more of them. That would be great, though, because all three of them are terrific to work with. Now, where to have this dinner? I would go someplace that I have not yet been but really want to visit, let's say, somewhere in Tuscany. Tuscan wines are wonderful, if we go there for dinner we can probably save on the price, the food would be terrific, we'd just need a location with a water view to make it perfect. Up on a hillside, around sunset, small local place.

AR: I only wish that I could make this happen. You've anticipated my next question: The theme of the 2011 U.S. Conference on Teaching Statistics was: The Next Big Thing. What do you think is the next big thing in statistics education research?

MS: At the ICME 12 meeting in Seoul this past July many of the presentations in the statistics topic-working-group were about informal inference. There is a growing movement in statistics education to (finally) seriously introduce simulation and re-randomization approaches to statistical decision making, both for secondary students and intro college stats students. Some of us in statistics education have been promoting this approach for decades, so it is not like this is a new idea. The ICME 12 stats sessions ended with some challenges to the young statistics educators who were in attendance to design some experiments to test out the growing body of evidence that informal inference is a better approach to introduce statistical decision making than appealing to theoretical probability distributions. Recent research suggests that tricky concepts like p-values, confidence intervals, margin of error might be more easily taught and understood by students through simulation and re-randomization approaches. I say let's test this out with some real statistical experiments.

AR: *Now I'll ask about the theme of this coming year's USCOTS: Making Change Happen. What is your attitude toward change: do you fear it or embrace it, or perhaps some of both? How has change played a role in your career? What thoughts do you have about how statistics educators can make change happen?*

MS: I grew up with change in mathematics education starting with my high school experience. As a freshman in high school I was told that half of the students in our school were going to have a 'new' mathematics program. Yes, I'm a New Math Boomer. So I had four years of SMSG (School Mathematics Study Group) experimental mathematics. Not only did I survive the new math, I thrived on it, majored in math, pursued it in graduate school, and felt (and still feel) that the over-zealous criticisms of the new math were misplaced and uniformed. There were a number of very good outcomes from the New Math movement, including that it planted the seeds for an entire generation of mathematics educators who have continued to work to change and improve the mathematical experiences of our K – 12 and college students. The goal for where we want the teaching of mathematics (and statistics) to be is very clearly outlined in NCTM's *Principles and Standards for School Mathematics. PSSM* contains the biblical blueprint for change, especially change in the *way* mathematics is taught in this country. We absolutely have to continue to embrace the changes recommended by *PSSM*, along with the similar changes outlined in the Standards for Mathematical Practice in the Common Core, or we will not make any progress for our nation's mathematics and statistics students. We'll just continue to spin our teaching wheels in a pedagogical rut.

Statistics educators have been building a good foundation for change, with the GAISE document and more statisticians becoming involved in developing resources for K – 12 teachers and students. And now with more statistics required, and tested, in grades 6 – 11 with the advent of the Common Core, statisticians and statistics educators have an unprecedented opportunity to help guide professional development for classroom teachers, and suggest materials and teaching approaches for statistics in middle and secondary schools. Statistics educators need to continue to grow the movement, get more statisticians involved, and help students and teachers learn how empowering the field of statistics can be. Data based decisions need to become the national norm, rather than basing decisions on whatever the latest opinion venting was from some radio or tv talk show. We need more empirical, and less fanatical, decision-making in this country.

AR: I know many college professors and high school teachers who embrace change, but I suspect that the teachers I meet at workshops and conferences are less averse to change than teachers in general. And I think it's fair to say that change can be intimidating and scary for many people, including of course teachers. Have you encountered much resistance to change as you've traveled the country meeting with teachers? What do you think can be done to help teachers who are hesitant to make changes, or perhaps skeptical or suspicious about calls for change? Or do you recommend focusing on the next generation of teachers and on those in the current crop who are willing to change? Or (one final possibility) perhaps you think I'm making too much of this idea of change in the first place.

MS: Most of the teachers that I have met with during my presidency are the ones who attend meetings and conferences, they are the go-getters, the ones who embrace new ideas and want to try them out. So I agree with you, our conference-attendees are not necessarily representative of our entire teaching force. There are many teachers who would rather not change how they have been teaching, or integrate new technology into their classes, because as far as they are concerned what they have been doing has been working well for them. I believe it takes teams of teachers working together to implement changes in their school and their classrooms. We are not all equally ready to try out new things, but with support from colleagues most of us would be willing to take a few new steps. If teachers see that something new that they do actually helps their students learn, they will jump on it. The common bond for all teachers is that they want to do what is best for their students to help them learn. The difficult part for all of us is to stick with a change long enough to see the impact on our students, to see some payoff. It can take some time when we implement new teaching practices or new curriculum materials to see improvements in student learning and attitude, we have to be patient with both ourselves, and the teachers we are working with, and we have to stay the course.

AR: Well said, thanks. Here's an easier (I hope) question: What is (or was) your favorite course to teach?

MS: There actually are three of them, but one stands out even among the three. I had a great deal of freedom to develop courses for middle and secondary teachers during my career (thank you to both OSU and PSU!) and the geometry and statistics courses for pre-service teachers were among my favorites. But the course that I most liked to teach above all was the Problem Solving for Middle School Teachers course at Portland State. Both my students and I worked harder in that course than any other course I've ever taught. Problems dealt with many different parts of mathematics and statistics content (counting, number theory, geometry, data analysis, probability, algebra) but the variety of approaches and strategies that the students shared for those problems, and the correspondence between myself and the students on their work on those problems was the best interaction of any course I've taught. I've pulled teaching approaches and assessment strategies from that class into all the other courses I have taught. The Problem Solving course gave me 'permission' to try some things in all my other courses. During my Presidency I ran a monthly column in the NCTM newsletter *Summing Up.* The column was called Problem to Ponder. Many of the problems in my Problem to Ponder column came from the bank of problems I assembled over the years for the Problem Solving for Middle School Teachers course. That column was one of the most enjoyable parts of my presidential experience.

Parting Thoughts

AR: Thanks very much for taking the time to participate in this interview, Mike. I've really enjoyed it and have learned a lot. I appreciate how much thought you've put into your responses, which have been quite inspiring. I have just two questions left. First, among your many accomplishments in statistics education, which one (or two, if you insist) are you most proud of?

MS: One contribution I'm proud of is the research I've been able to conduct and share on students' learning and thinking in statistics. This includes some of my own publications starting with an article in 1977 in *Educational Studies in Mathematics* (Shaughnessy, 1977) right up to a recent article I co-authored in the *Journal of Research in Mathematics Education* (Noll and Shaughnessy, 2012). I'm also quite proud of the contributions I made to the field in my chapters on research in probability and statistics in the *First and Second Handbooks of Research in Mathematics Teaching and Learning* (1992, 2007).

Another accomplishment I'm quite proud of is managing to get a Ph.D. program in mathematics education approved at Portland State University, and then mentoring and supervising a number of graduate students in that program who did their doctoral research in statistics education.

AR: Thanks, and I especially appreciate your reminder that working with students is always something that professors should value and take pride in. My last question is: What advice do you have for JSE *readers who are fairly new to statistics education?*

MS: Where to start—there are so many resources and supports available for statistics teachers and statistics educators now, it's a whole new world from when I first started out many years ago.

First of all, if you aren't already a member, join ASA as that will provide the information, networking, and professional development opportunities to grow into any other suggestions I will make. Read the GAISE report. Read the NCTM *Principles and Standards* document on NCTM's recommendations for teaching probability and statistics—most of those standards and recommendations apply equally well to college statistics as to K – 12 statistics. Log on to the statistics resources housed at the University of Minnesota through Causeweb.org for access to ARTIST, information about CAOS, and many other projects that have been created through CAUSE over the years. Attend a meeting of USCOTS (there will be one later in the spring of 2013), the U.S. Conference on Teaching Statistics. Plan to attend and perhaps send a proposal in to speak at the 9th International Conference on the Teaching of Statistics (ICOTS) conference to be held in Flagstaff, Arizona in July 2014). ICOTS has been the best professional boost for me as a statistics educator over my career. Finally, find other statistics teachers and statistics educators in your area, and set up regular meetings or a seminar with them. Statistics education is truly a communal adventure. Those of us who teach or do research in statistics are usually abnormally bubbly about statistics, and the excitement that it can bring to our students as they learn it. May the Statistics Force be with you!

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