TRANSFORMING THE TEACHING AND LEARNING OF STATISTICS: A MULTIDIMENSIONAL APPROACH

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The teaching and learning of statistics at the post-secondary level have gained substantial attention from the statistics education community in the past five years. Researchers have begun to focus on statistics instructors at two-year colleges in the United States. One such endeavor is the TANGO Stat Ed program (Training a New Generation of Statistics Educators), a National Science Foundation (NSF) funded program that focuses on a multidimensional approach to improving statistics content knowledge of instructors at two-year colleges. Combining years of experience with prior research and lessons learned from the TANGO Stat Ed program, a set of tools and strategies will be shared providing a multidimensional approach for professional development where each element fits into the bigger picture of statistical thinking and transformational thinking.

BACKGROUND

Two decades of teaching and learning statistics have provided me many experiences that shaped my perception of statistics. There was, however, one pivotal moment that made me switch my focus. I grew up in Argentina with an intense desire to find peace within. I took myself to India at the age of 21 and spent 15 years as a monk meditating many hours a day. I am sharing this because it taught me to be in the moment and to become self-reflective and introspective when uncomfortable things happen.

Fast-forward a few years. I had finished my master's degree in statistics and was in California at Santa Barbara City College tutoring students. One day, a girl with orange hair walked in. She had tears in her eyes. She threw her books down in a rage and said, "I hate statistics!"

At that uncomfortable moment, I paused and considered whether I might be like that student's teacher, one who frustrated her students. Seeing her frustration and the frustration of scores of other students, I was intrigued. I switched my research focus from students' difficulties with the content of statistics to researching those teaching statistics, to acknowledge the influence statistics instructors have over their students. This new focus gave me the tools to change myself as a statistics instructor first.

THE PROBLEM

As I became submerged in my statistics education literature research, I came to realize I was not exempt from the misconceptions students had. I remember clearly when I read an article by Watson (2007) about the arithmetic mean, presented as a simple idea in my book. She showed different ways to interpret, understand, and misunderstand the arithmetic mean. It was eye opening. I had received my master's degree in statistics with an impressive GPA. I had completed the proof of many mathematical and statistical theories. Yet I did not know what the arithmetic mean meant. This was humbling and shocking to me. Then, when I read Michael Shaughnessy's work about sampling distributions, I

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realized the gaps in my understanding were not minor. Participating in USCOTS (United States Conference on Teaching Statistics) and reading Robert delMas' (2007) work on standard deviation challenged me to think outside of formulas. I realized quickly all that I did not know. I began to see myself in each of these papers as a student with misconceptions. I saw gaps in my understanding and with it came shame and disappointment. At the same time, I gained the strength and the fascination to discover why I had those gaps and misconceptions.

Research before my dissertation gave me the tools and a great foundation for a deep conceptual understanding of statistics. I was happy and excited to face my misconceptions and change the way I taught statistics, slowly implementing all the tools, making the right connections, and correcting my teaching so students could avoid common misconceptions too. In the same research articles, I realized that most papers and research focus on either students or high school or elementary schoolteachers, but not so much on higher-education instructors. I decided to focus my dissertation on higher-education statistics instructors.

I noticed that most articles on statistics education ended with suggestions and ideas for teachers to follow to minimize students' misconceptions. It was not that the suggested ideas were wrong. They were not; I use them all and continue to be aware and hungry to grab new tips or ideas from role models, researchers like Robert delMas and others. The problem I saw was that many researchers were not considering the instructors' ability to implement those ideas. Here I was with a great GPA and a master's degree in statistics with several years of being a statistics TA, yet I had many holes in my statistics understanding. I wondered how other instructors, who did not have any training in statistics, could implement those tips. I resolved to investigate that issue in my PhD work.

I discovered from published research papers that often students' misconceptions were difficult to resolve even when a course was designed to avoid such misconceptions. For example, students still could not understand histograms (Carl Lee, Maria Meletiou-Mavrotheris 2005). This challenge piqued my interest even more because those researchers were leaders of statistics education. Yet they were also struggling to convey the intricacies of statistics concepts. Now I was hooked. I really wanted to understand all the gaps and become part of the solution and not part of the problem.

I learned there were 118,000 students taking statistics at two-year colleges in the USA during the fall of 2005, and only 2% of those teaching statistics held a degree in statistics, according to the CBMS (Conference Board of the Mathematical Sciences ─ survey of 2005).

With these figures in mind, I started with a pilot of seven professors. Next, I surveyed 55 professors from 33 different California colleges. What I found was that these statistics instructors had as many misconceptions and gaps as did I before getting involved with my research (Dabos 2011). I did not publish these results. Instead, I began looking for solutions to this newfound problem.

POSSIBLE SOLUTIONS

Here is where my years of experience again played a critical role in designing a professional development program, one that later became a substantial National Science Foundation grant. During my career, I was not only teaching and researching statistics, I was also involved for ten years as a co-coordinator of a program to help students succeed in college: The College Achievement Program at Santa Barbara City College in California led by Dr. Jody Millward. In that program, we first considered the demographics of the students (each semester was different). We then formed groups of

students with similar characteristics, (parents going to school, returning students, new to college students, working full-time students, et cetera). Then, we assigned them to a student mentor who had been in college longer and had similar challenges to their mentees when they started college. Jody and I coached the mentors and met with mentees, helping many so-called "at-risk students" succeed in college. Over the past ten years, we have seen students in gangs become award-winning engineers, leaders in their fields.

I wanted to do the same with instructors, but I needed to understand them better. I needed to understand their needs and characteristics and assign them a mentor in their field who could relate to them. Through my dissertation work, I learned a lot about instructors' struggles and frustrations. While collecting data for my dissertation, I specifically recall the first time an instructor shared with me her frustration teaching statistics. She had to teach it even though she knew she was not prepared to do so. Administrators required her to teach statistics courses because of the college's needs. She told me about feeling vulnerable in front of her students especially when she could not answer legitimate statistics questions. I also knew firsthand the struggles of part-time instructors who teach at different institutions having different textbooks and technologies. Some institutions did use some form of technology, while other institutions did not even permit using a calculator. I believe we are now over that issue of no technology usage, but the challenge continues for part-time instructors because not every college has the same technology. Then, there are also instructors, perhaps in the majority, who think they know what they are teaching until they stumble over their misconceptions.

My tutoring times, my life in temples, my ten years with the mentoring program at SBCC, my dissertation research, my informal chats with instructors, and my teaching prepared me to find a solution to some of the found gaps. Thus, my goal was to apply for a grant and, given the scope of the problem, find a collaborator.

Dr. Michael Posner and I met at JSM (Joint Statistical Meeting) in San Diego in 2013. We discovered we shared an interest in professional development. While his field of research had not been focusing on higher-education instructors, he understood immediately the need and opportunity to make a difference. Our work together led to a $575,000 grant funded by the National Science Foundation (DUE 1432251) to make the first attempt to help instructors and researchers bridge the gaps found in my journey. Training a New Generation of Statistics Educators (TANGO STAT ED) will give us three more years of awareness and realizations.

Though the TANGO STAT ED grant, we worked closely with 61 instructors from 36 colleges in four regions of USA: Northern California, Sothern California, Pennsylvania, and Florida. TANGO Stat Ed has three main parts. First, we pair faculty who teach statistics at the community colleges with mentors. Second, we develop several training sessions, two of which were held at USCOTS (United States Conference On Teaching Statistics) 2015 and 2017 so faculty got immersed in the statistics education community. Third, the faculty also participated in regular professional learning community (PLC) meetings where face-to-face interactions were essential. What we have learned through this grant so far is that instructors are eager to learn and improve their teaching. They get excited about teaching when they too see and experience the power of conceptual understanding.

We learned that instructors who applied for our program were not the ones with the most misconceptions but those who wanted to improve what they already knew. We further learned that face-to-face interactions build trust and community. We learned that the old systems or administrators sometimes resist instructors' implementation of change. We learned that many of them are now leaders

on their campuses. They present at conferences and they continue to be eager learners of statistics. Researchers now understand a bit better the challenges that college instructors have and many are realizing the need for the professional development of this population.

DISCUSSION

The set of tools essential for developing professional development programs includes a clear understanding of the population you want to serve. Also, one must avoid the great tendency in education to try fixing a problem while looking from only one perspective. Students' difficulties are only a part of the equation and not the entire source of the problem. Outdated or inaccurate textbooks need to be considered. Moreover, before continuing to offer a plethora of webinars for professional statistical training, a serious research endeavor needs to be implemented. It is important to test the effectiveness webinars have in developing comprehensive statistical knowledge that can be taken into the classroom. Also, consider supporting instructors' desire to use effective new teaching approaches by reducing the administrators' resistance to change. Provide ongoing support, not a onetime fix all. Avoid Band-Aid solutions. Investigate instructors' motivations, not only in statistics but also in teaching in general. One instructor told me that he preferred to be a part-time instructor because he made more money than a full-time instructor. He was teaching more than ten statistics courses in several institutions. He bluntly told me that his focus was on income, not on imparting knowledge.

Another fact to consider is that in a ten-year period (the CSBM surveys of 2005 and 2015), we noticed an extraordinary increase in the number of students taking statistics in the USA from 118,000 to 277,000, a 135% increase. The percentage of faculty with a degree in statistics teaching those students increased from 2% to 5%. This means that 256,150 of the students are taught by those without a degree in statistics. While degrees do not guarantee adequate statistical knowledge, nor the dedication to acquire the necessary knowledge, nor their teaching skills or PCK (pedagogical content knowledge), these figures need to be considered when creating professional development programs.

In short, understand the complexity associated with the problem of teaching and learning statistics by considering a multidimensional approach and recognize the implications of changes in the classroom.

REFERENCE

Conference Board of the Mathematical Sciences. (2015). *CBMS Survey Results*. Retrieved May 10, 2017, from http://www.ams.org/profession/data/cbms-survey/cbms2015-work

Dabos, M. G. (2011). *Two-year college instructors' conceptions of variation*. (Doctoral Dissertation) Retrieved from https://iase-web.org/documents/dissertations/11.Dabos.Dissertation.pdf

delMas, R. C., & Liu, Y. (2007). Students' conceptual understanding of the standard deviation. In M. C. Lovett & P. Shah (Eds.), *Thinking with Data* (pp. 87-116). New York: Lawrence Erlbaum Associates.

Shaughnessy, J. M. (2007). Research on statistics learning and reasoning. In F. K. L. Jr. (Ed.), Second *Handbook of Research on Mathematics Teaching and Learning* (*Vol. 2*, pp. 957-1009). Reston: National Council of Teachers of Mathematics.

Watson, J. M. (2007). The role of cognitive conflict in developing students' understanding of average. *Educational Studies in Mathematics*, *65*(1), 21-47.