

IMPROVING STATISTICAL PEDAGOGY AMONG K TO 12 MATHEMATICS TEACHERS IN THE PHILIPPINES

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This paper presents the collaborative efforts of a university, an international non-government agency and the government's Department of Education in an on-going five year teacher development project designed to enhance mathematics teachers' pedagogical content knowledge for teaching Statistics and Probability across the K to 12 Mathematics curriculum in the Philippines. The project comprised three phases: (1) capacity building of workshop facilitators and course development, (2) implementation of workshop-based courses for elementary, junior and senior high school math teachers; and (3) development of a support structure with online system for participating teachers. Using pre and post-workshop assessments, we analyzed and document teachers' knowledge and pedagogical skills for teaching various topics in Statistics and Probability within their levels.

BACKGROUND

Statistics education in the 21st century have been confronted with many challenges in response to national reforms in educational systems, emerging global standards and desired learning outcomes for students, and the dynamic nature of Statistics as a discipline in the face of evolving innovations in information and communication technologies. Tishkovskaya & Lancaster (2012) have provided a comprehensive summary of these challenges from various perspectives and have pointed out that one of the major directions of the statistics education reform movement is in pedagogical reforms toward development of conceptual understanding and teaching for statistical thinking and reasoning. From a global perspective, most of these reform efforts are directed towards the teacher as the key driver of successful curriculum implementation [see for example, North, Gal & Zewotir (2014); Sorto, (2011).] As with any area in education, the quality of teaching offered to students depends heavily on the continuing professional development of teachers, that is, their in-service training and preparation in order to cope with the demands and challenges of curriculum reform and the contextual realities of this modern Age of Information.

In developing countries like the Philippines, sustaining teachers' professional development through seminar-workshops requires much financial outlay yet their impact on teaching practice is not well established. Hawkes & Romiszowski (2001) contended that many educational reform efforts targeting improved student outcomes have been unable to produce the kind of desired learning outcomes and they attributed this failure to the lack of sustained, serious, systemic investments in the knowledge base of individual teachers. While extensive teacher training is a common implementation strategy for any curriculum reform, Sahlberg (2006) argued that it is not sufficient for successful change that typically involves people's awareness, knowledge, skills and beliefs. Hawkes & Romiszowski (2001) claimed that to achieve a clearer vision of improvement in the current school reform requires an expanded recognition of teacher development needs. In science and mathematics education, Loucks-Horsley, Love, Stiles & Hewson (2003) assert that professional development programs should pay explicit attention on the range of knowledge bases that teachers need for teaching, including teachers' content knowledge, pedagogical knowledge, and beliefs about teaching and learning. Thus, there is the need to re-conceptualized teachers' professional development to enhance teachers' professional knowledge bases, including curriculum knowledge, for better implementation of a reformed statistics and probability education.

PREVIOUS EFFORTS

In the Philippines, Reston and Bersales (2008) examined individual and institutional reform efforts made to address the need to equip statistics teachers with the pedagogical content knowledge and skills in teaching Statistics and Probability across the curriculum. The results showed the dearth of statistics majors in the teaching force with the majority of teachers'

undergraduate background in mathematics. With the implementation of the *K to 12* Basic Education reform in 2012, the teaching of school mathematics now includes Statistics and Probability as a learning domain from Grades 1 to 10 and as a stand-alone core course in Senior High School Grades 11 or 12. This expansion of the basic education curriculum recognized the importance of Statistics and Probability in this modern Age of Information where statistical literacy and competence with data and information are indispensable part of what is collectively known as 21st century skills. Further, the mathematics curriculum framework identified the development of problem solving and critical thinking as the central twin goals of mathematics teaching, and the pedagogical approaches are grounded on the underlying learning principles and theories of Constructivism and a spiral progression approach to curriculum design (Department of Education, 2013).

In response to these challenges of the *K to 12* Basic Education reform, we conducted a needs assessment study in 2014 using a cross sectional survey with 111 science and 92 math teacher respondents from 17 randomly selected public and private schools in Metro Cebu, Philippines. Teachers' professional development needs were assessed in terms of their content, pedagogical and technological knowledge bases for teaching their respective subjects, along with their teaching practices and teaching self-efficacy beliefs. The results showed that for the mathematics teachers, the teaching of *Statistics and Probability* was identified by majority of the teachers (66.3 %) as the learning area with greatest need for professional growth in terms of their pedagogical content knowledge for teaching the subject using the spiral progression approach (Reston, 2016). It is in this context that this paper presents an on-going five-year project that seeks to address this need for capacitating teachers to teach Statistics and Probability across the curriculum.

PROJECT DESCRIPTION

This project entitled *Improving Statistics and Probability among K to 12 Mathematics Teachers in the Philippines* is an ongoing five-year project of the University of San Carlos (USC) in Cebu City, Philippines with expert support from Academics without Borders (AWB), a non-governmental organization based in Montreal, Canada. It aims to: (1) enhance teachers' pedagogical content knowledge (PCK) for teaching statistics across the newly implemented K to 12 Basic Education curriculum in the Philippines; (2) assist in the development of materials that can be used in workshops for practicing teachers; (3) develop a support structure for practicing teachers which could include online support. In order to meet these goals of the project, it is implemented in three phases.

Phase 1 of the project comprises one year capacity building of workshop facilitators along with the development of activities for the workshops. During this phase, mathematics and statistics education expert and AWB volunteer, Dr. Pereira-Mendoza, facilitated workshop sessions to capacitate the teacher-facilitators. Moreover, prior to the training of workshop facilitators, a focus group discussion with elementary and secondary mathematics teachers was conducted to solicit expectations for the type of activities that they can use in their teaching of statistics within the school mathematics curriculum. Their responses focused on the need for teaching-learning activities that connect statistics to real world situations and local contexts, promote active learning and conceptual understanding, enhance students' motivation and appreciation of statistics, as well as integrate technology and other relevant resources. These responses were taken into consideration along with the conceptual framework of the *K to 12* mathematics curriculum provided by the Department of Education. The series of workshops focused on teaching *Statistics and Probability* from Grades 1 through 10 for a period of one month. The teachers participated in workshop-based activities to develop their own capacities and later, designed their own activities. The second series of workshops for another month focused on teaching *Statistics and Probability* as a stand-alone core course in Senior High School. Throughout this period, the teachers were provided support and feedback on how they may improve their activities. Further, this phase has prepared the tertiary math teachers to facilitate their own workshops to practicing school teachers in Phase 2. In addition, the teachers produced two volumes of activity resource books entitled *Teaching and Learning Statistics and Probability in the K to 12 Curriculum*. Volume 1 comprise activities from

Grades 1-6 for elementary math teachers while Volume 2 comprise activities for Grades 7-10 (Junior High School) and Grade 11 (Senior High School).

Further, the *K to 12* curriculum is standards-based and adopts the spiral progression approach to teaching and learning. Following the framework of standards-based curriculum development, the process starts by identifying the grade level content and performance standards as bases for designing activities to help students develop the learning competencies which are indicators of the standards. Anchored on Bruner's model of the spiral curriculum, spiral progression requires that the concepts and skills are built upon each other from the simplest, most concrete and familiar in Grade 1 level, and moving to the next grade level in increasing depth and complexity. With all these specifications, mathematics teachers are then faced with the challenge of achieving the goals of mathematics teaching using mathematics content media and appropriate learning activities relevant to the contexts of Filipino learners.

Phase 2 of the project consists of the on-going implementation of workshop-based courses held in parallel sessions for elementary, junior and senior high school math teachers. While workshop activities were anchored on the curriculum standards and learning competencies specified in the curriculum guide, they were also designed to engage students with the statistics and probability content materials in more meaningful contexts that they can relate to everyday life. The underlying learning principles and theories of Constructivism, Experiential and Situated Learning, Reflective Learning, Cooperative Learning, and Discovery and Inquiry-based Learning as cited in the *K to 12 Curriculum Guide for Mathematics* (Department of Education, 2013) support that "*learning is situated in activity*" and not in passive reception of transmitted knowledge. The workshops consisted of three-hour sessions per topic for eight sessions spread over four to five days. The workshops engaged the teachers in a wide range of activities that they may use in their own classes to enable students to build conceptual understanding of statistical concepts and processes through activities.

SOME RESULTS

A total of 102 mathematics teachers participated in the first two batches of workshops, comprising elementary teachers (25%), junior high school teachers (37%) and senior high school teachers (38%). Prior to the engaging the teachers in the activities for the workshops, pre-assessments were obtained on their level of familiarity of the topics in the curriculum for their level and their confidence to teach those topics.

Results of pre-assessment showed that of the 25 elementary (Grades 1-6) teachers who participated in the workshops, their perceived level of familiarity of the topics ranged from 72% to 94% only with the topic on double bar graph as their least familiar and data collection as their most familiar topic. The statistics component in the elementary mathematics curriculum focused on simple data representations from pictographs to bar charts, line graphs and pie charts. In the probability component, the language of uncertainty is introduced, with the concept of "50%-chance" as the least familiar topic for the teachers, and the concept of "likely to happen" as their most familiar concept. As to their level of confidence to teach these topics, their pre-assessment results showed that 72% of the teachers replied *Not Confident* and 28% said they were *Confident* to teach these topics. After the workshops, their perceived confidence to teach these topics shifted with 96% of the teachers asserting they were *Confident* to teach the topics. As part of qualitative evaluation, the following were some responses from the elementary teachers when asked what they like best in the workshops:

- *I like that we were formed into a group according to our levels, where activities are group/age-appropriate for elementary (Elementary Teacher 1)*
- *I was able to discover that we can teach statistics and probability in a simple manner and with practical activities (Elementary Teacher 2)*

For the Junior High School (JHS) teachers teaching Grades 7-10, the statistics component includes concepts of Statistics as a body of knowledge comprising data collection and reduction with particular focus on the descriptive summary measures of central tendency, variability and position. For the probability component, the topics include statistical experiments, sample space, counting possible outcomes, calculating probabilities for simple and compound events, and the

concepts of permutations and combinations for counting possible outcomes. The pre-assessment results on their level of familiarity of the topics showed that most of the teachers (70%) consider the Measures of Central Tendency as their most familiar topic and (23%) of them consider the Measures of Position as their least familiar topic. Some qualitative remarks of the teachers' reflections and evaluation of the workshop include the following:

- *Activities were very engaging and fun. I had a great experience. (JHS Teacher 1)*
- *The key features in the workshop activities are all relevant to my teaching. It would be most relevant in my class that I should engage the students in different activities that would enhance their capability in dealing with data (JHS Teacher 2)*

For the Senior High School (SHS) teachers, the workshop pre-assessment revealed that majority (68%) of them perceived a lack of confidence to teach the topics before the workshops since they were the first batch of teachers to implement the new senior high school curriculum. The topics include random variables and probability distributions, the normal distribution, sampling distribution and the Central Limit Theorem, estimation of parameters and hypothesis testing. Their evaluation of the workshops may be gleaned by the following remarks:

- *The workshops improved my content knowledge of the topics and showed me some strategies for teaching them. (SHS Teacher 1)*
- *I like the features of the workshops: Activity-based (Hands-on Activities), Collaborative Work (Sharing of Insights), Technology Integration, and Performance Tasks (Philippine-context)- SHS Teacher 2*

IMPLICATIONS AND FUTURE DIRECTIONS

The design of a more coherent, needs-based teacher development program for Mathematics teachers was conceptualized with some degree of flexibility to cater to different aspects of teaching the *Statistics and Probability* learning domain. The teacher development program is workshop-based and was designed to connect teachers' needs and current practices with the pedagogical approaches of the *K to 12* mathematics curriculum with the activities as venues for students to develop conceptual understanding and the stipulated learning competencies in the curriculum. While these workshops are still on-going, the next steps include the institutionalization of the implementation of the workshops for all three levels as part of the university's certificate programs for continuing professional development of the teachers. At the same time, we follow-up the teachers who participated in the workshops on their implementation of the activities in their own classes, and provide them needed support and mentoring through an action research approach for sustained professional development of teachers and improvement of teaching practice. We also intend to build a professional learning community of the mathematics/statistics teachers who participated in our workshops through a website where they are provided online support in terms of resources, and peer feedback and interactions.

REFERENCES

- Department of Education (2013). *The K to 12 Basic Education Program*. Retrieved June 2013 from www.deped.gov.ph.
- Loucks-Horsley, S., Hewson, P., Love, N. and Stiles, K. (2003) *Designing professional development for teachers of science and mathematics*. Thousand Oaks, CA: Corwin Press.
- North, D. , Gal, I. & Zewotir, T. (2014). Building Capacity For Developing Statistical Literacy In A Developing Country: Lessons Learned from an Intervention. *Statistics Education Research Journal*, 13(2), 15-27.
- Reston, E. (2015). Teachers' Knowledge Bases and Pedagogical Approaches for Implementing the K to 12 Mathematics Curriculum in the Philippines. *Proceedings of the 8th International Conference on Science, Mathematics & Technology Education*, Jakarta, Indonesia: Universitas Negeri Jakarta.
- Reston, E. & Bersales, L. G. (2011). Reform Efforts in Training Mathematics Teachers to Teach Statistics: Challenges and Prospects. In Batanero, C., Burril, G. and Reading, C. (Eds.) *Teaching Statistics in School Mathematics - Challenges for Teaching and Teacher Education: A Joint Study ICMI/IASE Study Book*. Heidelberg: Springer.

- Sahlberg, P. (2006). Curriculum change as learning: In search of better implementation. In P. Sahlberg (Ed). *Proceedings of the International Conference on Curriculum Reform and Implementation in the 21st Century* (pp. 18-30). Istanbul-Turkey.
- Sorto, M. A, (2011). Statistical Training of Central American Teachers. In Batanero, C., Burril, G. and Reading, C. (Eds.) *Teaching Statistics in School Mathematics - Challenges for Teaching and Teacher Education: A Joint Study ICMI/IASE Study Book* . Heidelberg: Springer.
- Tishkovskaya, S. & Lancaster, G. A. (2012). Statistical Education in the 21st Century: A Review of Challenges, Teaching Innovations and Strategies for Reform. *Journal of Statistics Education Volume 20*(2). www.amstat.org/publications/jse/v20n2/tishkovskaya.pdf