

## DEVELOPING STATISTICAL LITERACY AMONGST IN-SERVICE TEACHERS THROUGH A COLLABORATIVE PROJECT

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*Training teachers to promote statistical literacy in developing countries has to be very carefully planned to make the most effective use of limited resources available. In South Africa, an additional challenge of overcoming the generation of teachers that have a limited background in mathematics education, following the Apartheid era. The University of KwaZulu-Natal and Statistics South Africa have jointly introduced a program for promoting the teaching of statistics amongst in-service teachers (KZN maths4stats lecture series). This paper examines factors affecting the design of this simple intervention and its impact on teachers' attitudes towards teaching statistics, and reflects on issues in the planning of future intervention programs and related research that could improve the adoption of statistics instruction in developing countries.*

### INTRODUCTION

Research indicates that it is common for teachers to experience difficulty with teaching statistics topics due to lack of relevant knowledge and skills regarding content or pedagogy (Stohl, 2005). An additional factor, that has been identified as affecting teaching performance, is teachers' [negative] attitudes towards teaching statistics (Estrada, Batanero, Fortuny & Diaz, 2005; Martins, Nascimento & Estrada, 2013). Little however, is known about the impact of these factors on building statistics capacity at grassroots level in a developing country, where there are many additional challenges and barriers to teacher training, beyond just knowledge about content or pedagogy, as much as these are critical. This paper attempts to reflect on lessons learnt in South Africa about the effect of a small intervention on teachers' level of confidence about their ability to teach statistics topics, and highlight some of the issues that need to be addressed when aiming to improve capacity in statistics education.

A new school curriculum became policy in South Africa in 2002, following the end of the Apartheid era. Due to the recognition of the cross-curricular need for statistics, statistical topics were included at all levels (North & Scheiber, 2008). There was thus an urgent need for teachers to acquire the knowledge and skills required to teach this new topic in a meaningful way, at the primary or middle school levels, as well as at the high school level (in South Africa, these levels of education are designated as the General Education and Training or GET phase, comprising grades R to 9 and the Further Education and Training, or FET phase, comprising grades 10 to 12). This was in direct contrast to what had been the case previously, when statistics had virtually been totally absent from the school syllabus (North & Zewotir, 2006). This means that teachers did not know this topic existed or that it is often connected to mathematics education, and why and how it is important for future citizens.

In order to address the problem of providing some statistics training to over 10,000 mathematics educators in South Africa, Statistics South Africa launched the maths4stats campaign (North & Scheiber, 2008) in 2006, with particular focus on in-service teacher training. Though this program has been running in all provinces for a number of years now, there have been varying levels of successes due to logistic constraints and the sheer magnitude of the number of teachers that have to be trained. This in turn prompted the University of KwaZulu-Natal (UKZN) to give the maths4stats program in the province of KwaZulu-Natal (KZN) a boost, by setting up a collaborative project (KZN maths4stats lecture series), which aims at training in-service teachers in an organized, sustainable program that runs annually on several of the University campuses.

### THE INTERVENTION

The KZN maths4stats workshop series started in 2010, inspired by the hosting of the ISI's World Statistics Congress in 2009 in Durban on the East Coast of South Africa. It is a collaborative project between UKZN, Stats SA (a national statistics office) and the national Department of

Education (DoE) and aims to promote the teaching of statistics at schools in the province of KwaZulu-Natal. Teachers eligible for invitation are identified by the DoE, with the criteria for selection being that the school is a disadvantaged school in the province of KZN, i.e. is in need of improvement compared to other schools in the province. The KZN maths4stats workshop series was designed so as to give each of the three partners a distinctive role, with overall planning aiming to make the program as cost-effective as possible, so as to be sustainable in a country with economic constraints. Stats SA handles all matters related to contacting teachers, the registration process, printing of materials and logistics of catering. Teaching materials (course notes) are developed by UKZN Statistics lecturers. Workshops are presented by voluntary UKZN Statistics academic staff members, over five weekends, in venues supplied by UKZN on their campuses.

The workshop is organized into a total of 25 hours of contact time, spread over 5 weekend sessions, as teachers cannot get released from schools during weekdays, and Statistics lecturers likewise have other duties during the week. Teachers are responsible for their own transport and costs, many coming from hundreds of kilometers away, for each of the five weekends. Teachers are given refreshments and a hot lunch at each session, to promote social connection and communication and given that many travel long distances to attend the workshop.

The number of participants in the program at any one time is large. Since 2010, 200-450 teachers have attended annually, with 2014 expected to yield 220 teachers. The participants in the workshop are split into three parallel tracks, with different foci for the primary level (GET Data and Probability (grades 1-9), FET Data (grades 10-12) and FET Financial Mathematics and Probability (grades 10-12). During the workshop series, teachers systematically go through all of the statistics topics in the school curriculum, at a level suitable for inclusion in a short program, and receive homework between weekends. A brief summary of topics is presented in the Appendix.

At the end of the 4th weekend, teachers are assessed by a written test. It is taken on an optional (voluntary) basis, with a "mystery prize" being presented to each participant that scores over 60% in the assessment, to encourage teachers to take the test and do well on it. Passing the test at a certain minimal level is a requirement of the Department of Education in order for the teacher to get a "certificate of proficiency". In 2012, the program was repeated on two campuses, with a total of 448 teachers registered. Amongst these teachers, 217 (48%) chose to write the test. Out of the teachers who were tested, 135 (62%) qualified for the certificate of proficiency by achieving over 60% in the assessment.

The math4stats program concludes with an Awards Day, i.e., the 5th session consists of three workshops or lectures (Casio calculator workshop; Stats SA census@school demonstration and SAS Curriculum Pathways demonstration). These are followed by the awarding of certificates of attendance (for those who attended all the lessons) and certificates of proficiency plus a "mystery prize" (for those achieving over 60% in the assessment). The awards are personally handed by the Statistician General (Mr. Pali Lehohla, Director of Statistics South Africa).

#### TEACHERS' CONFIDENCE IN TEACHING STATISTICS

To inform future planning of the project, a questionnaire was presented to participants during the 2012 KZN maths4stats series, both before they started the first session and again at the end of the fifth and final session. The questionnaire aimed to get an insight into the effect of the workshop series on teacher attitudes. Teachers were asked to rate their level of confidence in teaching Data Handling topics (Statistics), using a simple Likert-type scale with four ratings ("poor", "moderate", "good", "excellent"). Response scales were pre-designed to be short and simple in order to simplify administration and explanations amongst teachers, since the majority of the attending teachers do not have English as a home language, but rather Zulu. This situation is typical of field research in South Africa, where the language of teaching is English, but the spoken language is different for both teachers and their pupils.

Figure 1 presents results for the 252 teachers who attended all five sessions in the 2012 KZN maths4stats series. The graph highlights the positive shift in confidence in teaching statistics before and after the 5-weekend series.

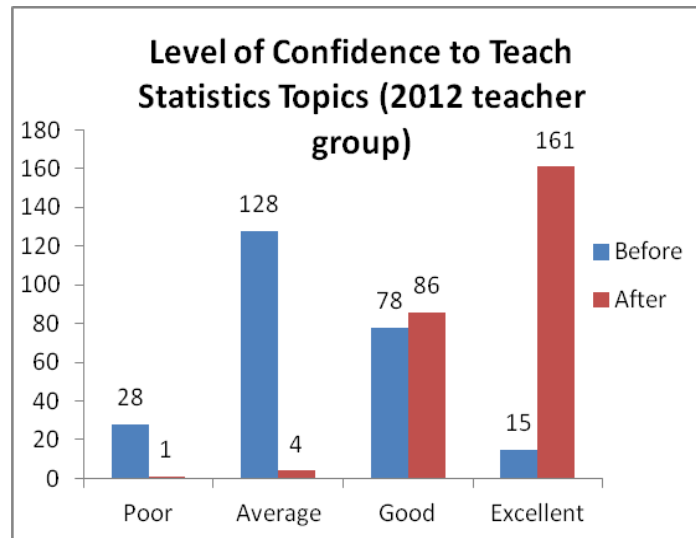


Figure 1: Teachers' ratings of confidence in teaching statistics, before and after a workshop

In particular, the following changes were noted over the duration of the workshop series:

- “poor” confidence category, dropped from 28 to 1
- “average” confidence category, dropped from 128 to 4
- “good” confidence category, increased from 78 to 86
- “excellent” confidence category, increased from 15 to 161

## CONCLUSION

The design of the KZN maths4stats program, by itself, offers a potent example for a new kind of a collaborative arrangement between three partners: a University, a ministerial department, and an official statistics agency. It shows that it is possible, and in fact essential, to build an intervention that benefits from the strengths, capacities, and institutional needs and goals of all partners, as well as that pools funding and resources to make it sustainable over time. However, such a program does not emerge by itself, and substantial discussions and negotiations, and some trial and error, were needed in order to find a working format that is reasonable not only for the partners, but also for the teachers who are expected to make a substantial investment of time, energy, and personal funds in a topic they know little about.

The program implemented a very simple pre-post evaluation design, dictated by the field conditions and need to maximize the use of the limited workshop time for teaching rather than for evaluation. Yet, despite the brevity of the rating scale of the questionnaire, it was able to capture sizeable changes in teachers' attitudes. The results show that the workshop format led to an improved level of teachers' confidence in teaching statistics, both for teachers whose initial confidence was low, as well as for those that were higher up the scale at the start of the program. Yet, teachers' level of knowledge as reflected in the proficiency test is a cause for concern.

Clearly we need to better understand the process and impact of the workshop series. Amongst other things, a program evaluation study has to be designed in advance, involving not only a summative evaluation regarding changes in knowledge and attitudes, but also a formative evaluation of barriers and blocking factors regarding teacher initial interest and willingness to participate, actual participation patterns, and post-workshop behaviours (e.g., did teachers implement in their classes any of the ideas learned in the workshop? if so, how and when?).

Finally, it is important to reflect on the contextual constraints and on the factors that affect the design and working process of the math4stats program, and their implications for the future of in-service workshops aiming to improve statistics education in South Africa and other developing countries. The present content of the math4stats program is focused on procedural or formal aspects of statistics and probability, with only small attention to interpretation and communicative aspects or to understanding of real-world (e.g., media-based) statistical messages. This situation stems from multiple factors, i.e., the curriculum specification in South Africa and expectations of

the Department of Education, the weak background of many teachers with the mathematics that underlie basic statistical procedures, and teachers' relatively low confidence. In addition, the linguistic diversity amongst teachers and students alike is such that it is difficult to develop interpretation and a critical discussion of statistical messages in the current program format. Further program time and additional resources are needed in order to introduce aspects of statistical literacy into the program, yet such time is not available, nor is it possible to involve teachers in small group work or in extended open-ended discussions given the large numbers of teachers that sit together due to logistical constraints. Addressing such issues clearly is a challenge in a developing country context and will require the introduction of new and longer interventions with different formats, additional funding, accompanied by a more rigorous evaluation design.

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## APPENDIX: Summary of content included in different workshop tracks:

*Primary level (GET grades 1-9) "Data and Probability"*: Collecting and Sorting Data (data types, surveys, questionnaires, populations, samples, tally tables, frequency); Displaying Data (pictograms, bar graphs, stem-and leaf plots, compound & sectional bar graphs, pie graphs, graphs for grouped discrete data; choosing the most appropriate graph); Analysis of Discrete Data (mean, median, mode, range).

*Secondary level (FET grades 10-12 "Data"*: The topics above are presented at a higher cognitive level, with further extension of working with continuous data, so that additional topics are added: grouping then analyzing continuous data (mean, median, mode, range, variance and standard deviation of grouped data), quartiles, interquartile range, outliers, Box-Whisker plots, regression and correlation, recognizing Normal distributions by interrogating the symmetry and proportion of values within mean $\pm$  std deviation.

*FET (grades 10-12) "Financial Mathematics and Probability"*: This track focuses on concepts of risk and certainty/uncertainty, linking them to financial and investment topics. Like in the "Data" track for FET outlined above, subtopics such as relative frequency of outcomes of a random experiment; events, classical definition of probability, calculating probabilities using tree diagrams etc are presented at a higher cognitive level. Further topics are added such as: basic set theory, Venn Diagrams, mutually exclusive events, dependent and independent events; conditional probability; calculating probabilities and conditional probabilities from 2-way contingency tables, counting rules, problem solving using probability rules, and more.