Developing Statistics Education in Kenya through Technological Innovations at all Academic Levels

1. INTRODUCTION

The value of using technology in education is no longer in question and has been shown to work even in underprivileged areas (Mitra, 2010; Mitra & Dangwal, 2010). For statistics in particular the guidelines and resources already exist and what needs to be done is generally accepted. However the changes have not yet happened in a sustainable way particularly in countries like Kenya where the teaching is still fundamentally based on a syllabus and approach from the 1960's.

The problem in Kenya, and in other countries in the East African region, is not a lack of initiatives but the lack of an educational culture which embraces and encourages these changes. The solution proposed is a change in postgraduate training designed also to nurture innovation in schools and universities.

2. THE STATEMENT OF THE PROBLEM AND ITS IMPORTANCE

There are well defined guidelines (Aliaga, et al., 2005; Franklin, et al., 2005) on how statistics needs to adapt to the modern technological world. As with many countries Kenya has recognized the need to adapt its statistics education for many years (Odhiambo, 2002). In particular, an initiative in the agriculture faculty of the University of Nairobi transformed statistics into their students' favourite subject (Kurji, McDermott, Stern, & Stern, 2010). This initiative and others has led to the availability of good free resources adapted for use in Africa (Stirling, 2005; VSN International, 2005; SSC University of Reading, 2007). But despite these and other initiatives the overall teaching of statistics in Kenya has not changed. Even the teaching to University of Nairobi agriculture students has since almost reverted back to more traditional methods.

If there is a global recognition that change is needed and initiatives have shown that it is possible and can be highly effective the main question that remains is why isn't the change taking hold and what can be done to make changes that stick. One way to get changes to take hold is to give recognition to original ideas thus creating a culture of innovation. The current Kenyan system does not encourage this as educational innovation is not recognised academically.

3. BACKGROUND

These ideas have come from working in Kenyan mathematics and statistics education over the last four years. Many apply equally to mathematics and statistics; contrary to some statistics educators belief that statistics education is too mathematical. The real issue is that both mathematics and statistics education have too much emphasis on calculation and formulae, and it is only recently that mathematics is joining statistics in looking for a technological solution to this problem. The initiative to look for change has taken various forms, most notably the project MOSAIC (Project MOSAIC, 2010) and the computer based math (Wolfram, 2011; Wolfram, 2010) initiatives.

Statisticians have been using computers in their teaching for over forty years (Sterling & Pollark, 1966) and some of the innovations taken then (Mead & Stern, 1973) are still applicable today (Stern, Latham, & Stern, 2009). So why are the established good practices not being adopted on a larger scale? This problem is in no way unique to Kenya and there have been some major initiatives, even

within Africa, trying to address this issue for statistics in schools over a long period of time (North & Ottavianni, 2002; North, 2006; North, Scheiber, & Ottaviani, 2010).

In Kenya, a large scale initiative, at school level, called SMASSE (Strengthening Maths and Science in Secondary Education) has involved the yearly training of almost all school science teachers for more than 10 years (Wambui & Wahome, 2006; Japan Internatinational Cooperation Agency, 2007). However despite all this training, for all this time, the sciences are still the major problem area in Kenyan school education.

A recent series of initiatives by Maseno University has led to small improvements at various academic levels (Stern, Ongati, Agure, & Ogange, 2010). This incremental approach allowed for interaction between the innovations at masters level with parallel innovations affecting school, diploma and undergraduate students. This interaction was not initially planned in this way but led to the idea that, in the Kenyan context at least, educational innovators should be working across all academic levels (Stern D. , 2011).

4. RELATED PREVIOUS WORK

Three recent initiatives illustrate how ideas introduced at postgraduate level have spread quickly into diploma, school and undergraduate programs. The first involved introducing an electronic statistics textbook, CAST (Computer Assisted Statistics Textbook) (Stirling, 2000), along with its electronic testing system into diploma teaching. The second introduces computers into schools as a tool to help the teaching of statistics in the mathematics curriculum. The third has been in undergraduate statistics courses at Maseno University.

4.1 CAST Introduced into a Business Diploma

This work started with Bernard Manyalla, an applied statistics masters student, who was also teaching on a local diploma program. Manyalla requested an MSc project related to educational innovations in his teaching. In his coursework his class had been amongst the first people to be taught using CAST exercises (Stern, Stirling, & Stern, 2009) to check their basic statistical knowledge. This experience led him to try using CAST in his teaching at KIM (Kenya Institute of Management). Manyalla obtained approval to teach using the exercises and did so, in December 2009, with a small first group of just six students. One student did not engage in the exercise, but there was huge enthusiasm and progress from the rest. This distinction was highly visible in the final centralised exam results, shown in Figure 1.

While Manyalla started introducing CAST and the exercises to his students, the exercises were being made into a testing system. CAST tests were used to teach the subsequent class of MSc applied statistics students in Maseno; this was one of the very first uses of the testing system in the world (Stern, Stirling, Dale, & Stern, 2010). Manyalla was able to observe the teaching and to learn what needed to be done so he could introduce the tests at KIM.

With his next set of students, in March 2010, the use of the exercises was combined with use of the new CAST tests as part of the continuous assessment at KIM. In both this period and the previous one there was a parallel set of students being taught by a colleague who was not using CAST and the difference in marks in the final centrally marked exam were clear. In Figure, “Stu” signifies the MSc student and “Col” the colleague.

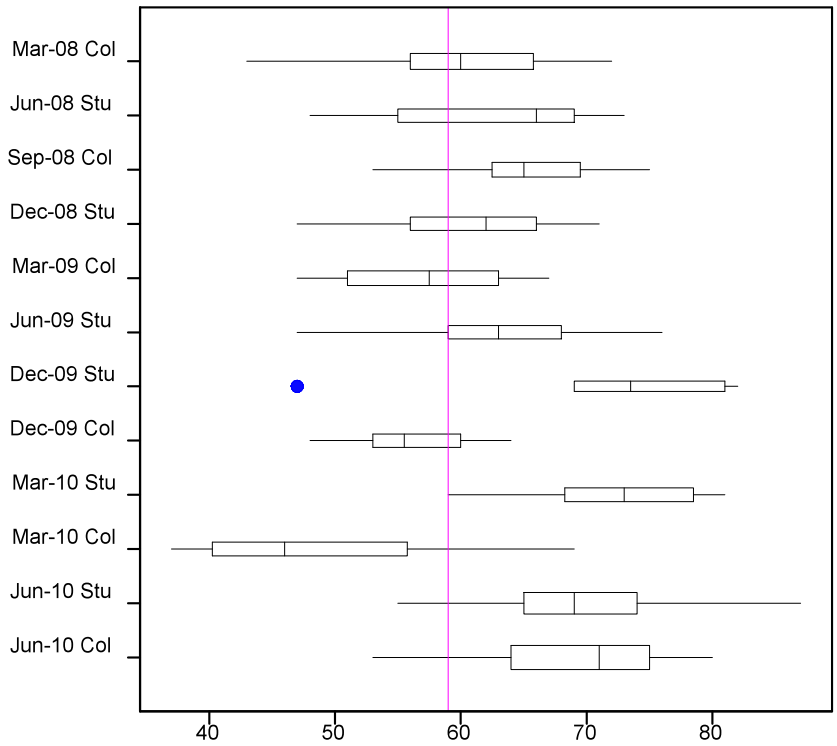

Figure 1:Marks from Kenya Institute of management with and without the use of CAST. "Stu" represents data from the MSc student and "Col" the colleague.

With the following intake, examined in June 2010, both Manyalla and his colleague used the exercises and tests, in an attempt to identify if the change was caused by his improved teaching or the resources. Both were teaching students of the same level and there was no difference between students' marks in the exams, which were marked centrally, but the marks were on average about 10% higher than the average marks their students were getting before using CAST. The details of this study are currently in Manyalla's MSc thesis (Manyalla, 2012). Overall the average mark for the 90 students who did not use CAST was 59%, and this was close to the National average. The average mark was just over 70% for the 77 students who used CAST.

4.2 Computers in School Statistics

In a subsequent year Zachariah Mbasu was keen to bring both CAST and the statistical package Genstat, which Mbasu had used for his Masters, into schools through teacher training. As many Kenyan teachers are not yet computer literate this would be combined with computer literacy training. Mbasu was able to convince organisers of a local SMASSE (Strengthening Maths and Science in Secondary Education) training to give a computer based training for science teachers in the region. This was the first computer based SMASSE training in the country and included a component on these statistical resources.

The SMASSE training was a moderate success. A few teachers were interested in the software and took the ideas back to their classroom, but the uptake was not high. One of the observations was that more than 80% of the time was spent teaching teachers simple computer literacy skills, mainly Word, Powerpoint, Excel, and learning to create an email address. It was felt that a training course which focussed on the use of the statistical resources as opposed to computer literacy might be more effective. This was tested in a subsequent training course where despite some teachers being initially computer illiterate at the start of the course they were able to make use of the statistical software resources after two days of training purely on CAST and Genstat (Mbasu, Stern, & Ogwel, 2012).

Assessing the impact on students in this environment has been much harder, as statistics is a small optional part of the end of school exam, so good quantitative evidence is hard to come by. There has been very positive feedback from both teachers and students when the resources have been used in teaching, but it is often commented that the resources need to be customised to the local syllabus and expanded to cover the full mathematics curriculum. So, as part of this initiative, Mbasu has also been adapting CAST for the statistics component of the Kenyan curriculum and looking for the appropriate electronic resources to cover the rest of the maths curriculum.

Mbasu's work has been recognised by the Ministry of Education, who have made him a regional ICT (Information Communication and Technology) champion with responsibilities for 10 schools in 2 regions, to help bring ICT into education. This ICT champion program is countrywide and related to the SMASSE training, so if these interventions can be shown to be effective there is the possibility of spreading them throughout Kenya.

4.3 Getting Undergraduates to Embrace Computers

Maseno University has a small number of graduate assistant positions in the department. This is a staff position where top undergraduate students are employed in the department while they are studying for a masters' degree. It is essentially equivalent to a full scholarship for a MSc with the added bonus that most graduate assistants are promoted and retained as teaching staff upon completion of their degree.

The existence of such positions and high probability of being retained within the department provides the opportunity for interested graduate assistants to use their time in the department as training for lecturing. One such graduate assistant, James Musyoka, who was a student during the initial innovations in the MSc took the initiative to write up these innovations from a student perspective (Musyoka & Stern, 2009) to gain further exposure by attending and presenting at a conference. During the project stage of his thesis Musyoka involved himself in opportunities that would help train him to become a lecturer (Musyoka, Otieno, & Stern, 2010).

Upon completing his MSc Musyoka was allocated a single course to teach within the department in his first semester and has used that opportunity to engage himself in changes in the undergraduate teaching (Musyoka, Stern, & Otieno, 2012). Through this initiative Musyoka has been involved with integrating computers into statistics teaching for a specific class of students over the last year and a half. These students have been introduced to statistics using spreadsheets and the statistics packages Instat and Genstat. Many of the students were completely computer illiterate before starting their degrees. Now all are both computer literate and have some skills in data handling.

One of the most interesting aspects has been that this has been achieved without having access to a computer lab. Initially the computer component was optional, but all students wanted to participate and found access through cyber cafes, mobile phones, or borrowed computers. At the end of the first year over 25% of the students had managed to acquire a laptop, and after two years this figure was over 50%. Every undergraduate course in Maseno University includes an IT component but the standard IT components have not generated this sort of interest from the students. A rough estimate puts the number of students in the university as a whole having a computer at less than 10%.

5. DISCUSSION OF MAIN ARGUMENTS

There have been many attempts to improve statistics education in Kenya, but they have not had the impact that was expected. In this section we mention two initiatives, one at school and the other at university level. We discuss why they have not had the success that was hoped for and offer suggestions about how they could be made more successful. We then summarise the ideas into a framework that discusses a cultural change which could lead to innovations being more effective.

The biggest initiative in Kenya is the SMASSE (Strengthening Mathematics and Science in Secondary Education) project. With Japanese funding and governmental support this project has achieved what would seem impossible to many. It has been giving in-service training to all Kenyan secondary mathematics and science teachers for more than 10 years. SMASSE implements a cascading approach where international experts with the latest ideas are brought in to train the first level of trainers, who train the second level and so on down to the teachers themselves who should then integrate the new methods into their teaching of the students.

A big question Kenyan policy makers are asking is why SMASSE has not had a noticeable impact on student performance? There are no easy answers but it is recognised that bringing technology into the training offers a chance to attempt a different approach. The component of the problem that technology can solve is access to good resources for teachers and students alike. Many good resources exist and recently New Zealand has taken the lead, updating their statistics syllabus and working to integrate resources including GenStat for teaching and learning (Andrews, 2010) and a version of CAST (Computer Assisted Statistics Textbooks) (Stirling, Public CAST, 2000) adapted to the new syllabus (Stirling, CAST for New Zealand Schools, 2011). As has been mentioned creating a version of CAST adapted to the Kenyan syllabus is already underway.

Many school teachers are looking for ways to broaden their opportunities and every year some teachers take the Maseno MSc course in applied statistics and other mathematical MSc's. In a few instances teachers have taken what they learned in their coursework and brought it into schools, but there are no institutional mechanisms for such an initiative to be supported by the university or recognised as part of their education. If a masters' degree provided teachers with ideas that that could be brought into their teaching and blurred the line between statistics and statistics education a number of teachers might be attracted to bringing initiatives back into their own teaching. The existence and structure of SMASSE means that when such interventions are recognised to work, it could be quick and easy to spread ideas around the country.

At university level in Kenya, over the last 20 years, a range of new 'more applicable' degree programs have been created. These include applied statistics and actuarial science at undergraduate and postgraduate levels, as well as MScs in biostatistics, social statistics and research methods. In general these new degree programs have been well thought out and constructed, sometimes with considerable international funding and expertise. However they are generally not being taught as they were designed and have a tendency to converge back to the traditional theoretical statistics teaching, as that is how the lecturers were themselves taught and what leads to a traditional statistics PhD.

The lecturers teaching these degree programs are always overloaded. A normal lecture load in Kenya is three full courses a semester and staff often also teach part-time, sometimes at more than one university as there is a shortage of qualified staff. Generally the lecturers with doctorates are either products of the Kenyan system, with its emphasis on theory, or they have recently completed international PhD's. In each case their own training is highly specialised and does not prepare them to become innovators in their own teaching.

Lecturers who do a Kenyan PhD also teach while studying, which leads to two serious problems. The first is that the depth of their knowledge suffers as they do not have the time to focus on research and the second is that they get used to teaching in a traditional way as it is all they can do within their time constraints. Those who go abroad for their PhD obtain the depth of knowledge required in their area of specialisation. However when they return to teach they often do not understand the Kenyan system and their attempts to change it meet resistance partly because their knowledge base is too specialised. The UK has recognised the fact that PhD students suffer from a lack of transferrable skills (Roberts, 2002) and is taking steps to rectify this, but these transferable skills are even more important for Kenyan graduates.

The heart of this problem is a mismatch between PhD holders in the international world, who would then do post-doctoral work before becoming lecturers, while Kenyan PhD holders are expected to be

fully qualified to play a guiding role in the department as soon as they complete their PhD as there is a severe shortage of doctorates. Neither international nor Kenyan doctoral training programs prepare graduates for the role they have in a Kenyan university. Devising alternative doctoral training or supplementing their existing training to prepares graduates for their broader role could provide part of the solution.

The two examples given above both illustrate the fact that innovation at one academic level can sometimes be best supported through innovation at another level. For Kenya to create the culture of change that is needed to develop statistics education through the adoption of technology, it is important to find ways to support potential innovators. Creating flexibility in postgraduate statistics education to accept educational innovation as an academic component of a degree could lead to recognition for innovators and opportunities for career progression.

6. IMPLICATIONS FOR CURRICULUM DEVELOPMENT

The need for curriculum change at school and undergraduate levels are well recognised. Such changes are achievable in Kenya if there is a sufficiently supportive environment for the innovations to flourish. An appropriate broadening of the postgraduate education could provide this nurturing environment.

Most Kenyan postgraduate students do their degrees part time and, up to now, this has always been a limitation, compromising the quality of the education given. By instead adapting the education to be more directly relevant to the student's current employment this could be turned from a limitation to an advantage, as ideas can perpetrate much faster. This has far-reaching educational implications when the students are themselves educators. For example, this could lead to the following two new programs:

- Development of a Masters degree which supports innovations in schools.
- Development of a professional doctorate program which recognises research in education as a component of a doctoral program in statistics.

Through such programs we could hope to achieve the following:

- Improved approach to curriculum reform through research at multiple levels.
- Improved communication between schools and universities which encourages a smooth transition for students.
- Recognition for contributions to teaching and learning at all levels which feeds back into professional development.
- Material creation as part of education at one academic level to serve education at another.

If such solutions were found for the Kenyan context, might there be implications outside of a developing economy context? It is not possible to know which aspects might be more generally applicable but there are examples that indicate that we should be trying to learn from solutions found under difficult circumstances (Leadbeater C. , 2010; Leadbeater & Wong, 2010).

REFERENCES

Aliaga, M., Cobb, G., Cuff, C., Garfield, J., Gould, R., Lock, R., Moore, T., Rossman, A., Stephenson, R., Velleman, P., Witmer, J. (2005). *Guidelines for Assessment and Instruction in Statistics Education Colledge Report.* American Statistical Association.

Andrews, S. (2010). Statistical software for teaching: relevant, appropriate and affordable. *ICOTS 8 proceedings.* Ljubljana: International Association of Statistical Education (IASE) .

Franklin, C., Kader, G., Mewborn, D., Moreno, J., Peck, R., Perry, M., et al. (2005). *Guidelines for Assessment and Instruction in Statistics Education Report.* American Statistics Association.

Japan International Cooperation Agency. (2007). *Analysis from a Capacity Development Perspective - SMASSE.* JICA.

Kurji, P., McDermott, B., Stern, D., & Stern, R. (2010). The growing role on computers for teaching statistics in Kenya. *Proceedings of the Eighth International Conference on Teaching Statistics.*

Leadbeater, C. (2010). *Charles Leadbeater: Education innovation in the slums.* Retrieved 1 18, 2011, from TED: http://www.ted.com/talks/charles_leadbeater_on_education.html

Leadbeater, C., & Wong, A. (2010). *Learning from the Extremes.* Cisco Systems, Inc.

Manyalla, B. (2012). The use of Computer Based Tests (CAST tests) and CAST exercises to improve the learning of statistics at tertiary level of education. *MSc Thesis*. Maseno, Kenya: Maseno University.

Mbasu, Z., Stern, D., & Ogwel, J. (2012). Improving the teaching of mathematics in kenyan schools via in-service training. The 12th *International Congress on Mathematics Education, Seoul, Korea.*

Mead, R., & Stern, R. D. (1973). The use of computers in the teaching of statistics. . *J. R. Statist Soc. A* (136), 191-204.

Mitra, S. (2010). *Sugata Mitra: The child-driven education.* Retrieved 1 18, 2011, from TED.

Mitra, S., & Dangwal, R. (2010). Limits to self-organising systems of learning—the Kalikuppam experiment. *British Journal of Educational Technology* , 14.

Musyoka, J. K., Stern, D., & Otieno, J. (2012). Using e-learning to engage Mathematics and Statistics Students in a Kenyan University. The 12th *International Congress on Mathematics Education, Seoul, Korea.*

Musyoka, J., & Stern, D. (2009). Using computers and problem-based approaches for postgraduate statistics teaching in Kenya. *IBS SUSAN conference proceedings* .

Musyoka, J., Otieno, J., & Stern, D. (2010). Training of lecturers at Maseno University, Kenya. *Proceedings of International Conference on Teaching Statistics 8.*

North, D., & Ottavianni, G. (2002). Statistics at foundation school level in South Africa - The way forward. In B Philips (Ed.). *Proceedings of the 6th International Conference on Teaching of Statistics.* Cape Town.

North, D., Scheiber, J., & Ottaviani, G. (2010). Training teachers to teach Statistics in South Africa: Realities and attitudes. *Proceedings of 8th International Conference on Teaching Statistics.* Ljubljana, Slovenia.

Odhiambo, J. W. (2002). Teaching of Statistics in Kenya . *Proceedings of the 6th International Conference on Teaching Statistics.* Cape Town.

Project MOSAIC. (2010, July). *MOSAIC*. Retrieved October 5, 2011, from MOSAIC: http://mosaic-web.org/

Roberts, G. (2002). *Set for success.* London: HM Treasury.

SSC University of Reading. (2007, September). *SADC Resource DVD*. Retrieved Febuary 27, 2011, from SSC University of Reading: http://www.reading.ac.uk/ssc/media/sadc-training-pack/

Sterling, T. D., & Pollark, S. V. (1966). Use of Computers to Teach Introductory Statistics. *Communications of the Association of Computing Machinery* (9), 274-276.

Stern, D. (2011). Introducing computers into mathematics through educational innovation at all academic levels in Kenya. *Proceedings of EDULEARN11 Conference.* Barcalona.

Stern, D., Latham, S., & Stern, R. (2009). Statistical games to support problem-based learning. *IBS SUSAN Conference proceedings.*

Stern, D., Ongati, O., Agure, j., & Ogange, B. (2010). Incremental modernisation of statistics teaching and curriculum at Maseno University, Kenya. *Proceedings of 8th International Conference on Teaching Statistics.* Ljubljana, Slovenia.

Stern, D., Stirling, D., & Stern, R. (2009). Improving the learning of statistics with computer based exercises. *IBS SUSAN conference proceedings.*

Stern, D., Stirling, D., Dale, I., & Stern, R. (2010). The use of computer-based tests to consolidate statistical concepts in Kenya. *Proceedings of 8th International Conference on Teaching Statistics.* Ljubljana, Slovenia.

Stirling, D. (2005). *CAST for Africa*. Retrieved August 23, 2010, from CAST: http://cast.massey.ac.nz/collection_african.html
Stirling, D. (2011). *CAST for New Zealand Schools.* Retrieved Febuary 27, 2011, from CAST: http://cast.massey.ac.nz/ncea
Stirling, D. (2000). *Public CAST*. Retrieved August 23, 2010, from CAST: http://cast.massey.ac.nz/
VSN International. (2005). *GenStat Discovery*. Retrieved January 15, 2011, from Genstat: http://www.vsni.co.uk/software/genstat-discovery/
Wambui, N. N., & Wahome, A. N. (2006). *Report on SMASSE Project.* Retrieved 2 26, 2011, from CRICED University of Tsukuba: http://www.criced.tsukuba.ac.jp/math/sympo_2006/nui.pdf
Wolfram, C. (2011). *Computer Based Math*. Retrieved 3 31, 2011, from http://computerbasedmath.org/
Wolfram, C. (2010). *The Practical Approach to Maths Education.* Retrieved March 29, 2011, from Wolfram Research: http://www.wolfram.com/solutions/highered/usformat.pdf