MEASURING THE EFFECTIVENESS OF USING COMPUTER ASSISTED STATISTICS TEXTBOOKS IN KENYA

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There is currently a big push to integrate technology into Kenyan education at all levels. Statistics is a subject that can benefit immensely from this improved access to technology. This study attempts to quantify the effect Computer Assisted Statistics Textbooks (CAST) has on student interest and performance. In Kenya CAST has now been used across all academic levels from schools to postgraduate, the implementations in a Diploma program is such that it allows for a quantitative analysis of performance against standardised grading, while the implementation in schools led to good data on student motivation. These implementations will be the focus of this paper.

INTRODUCTION

The present Kenyan government has initiated a project to provide a laptop to every student joining standard one as a curriculum reform agenda. In this project, every standard one pupil (aged about 6) receives a laptop containing digital resources to help facilitate their learning. These resources will cover all the subject areas that are examinable under the Kenyan curriculum. There is also an effort to equip secondary schools, middle level colleges and universities with computers to facilitate learning. The beneficiary institutions have the freedom to introduce and use any resource of their choice while the learners are provided with an opportunity to access the rich variety of digital content available.

Technology is an inseparable part of a modern statistics course (Gould, 2010); the value of using technology is no longer in question and has been shown to work even in underprivileged areas (Mitra & Dangwal, 2010). There are well defined guidelines on how statistics needs to adapt to the modern technological world. Computer Assisted Statistics Textbooks (CAST) (Stirling, 2005) was introduced to Maseno University's postgraduate students in 2008 (Stern, Stirling, & Stern, 2009). The lecturer used CAST exercises to check their basic statistical knowledge. From there, CAST was used as a resource for diploma students at the Kenya Institute of Management (KIM). The resource was further introduced to secondary schools through teacher training.

The need to modernize statistics education in Kenya has been recognised for many years. In schools and colleges, learning is characterised by reading selected textbooks, taking notes regularly, and the emphasis is on mathematical formulae. At all levels, the teaching of statistics is still primarily theory-based. Bringing computers into education provides the opportunity to change the way of teaching.

In the official curriculum document for the Kenya Institute of Management, (KIM) a statistics module is one of the six mainstream modules for all students taking a diploma in Management. Each module includes about 45 contact hours spread over 10 weeks. The statistics module includes: presentation of quantitative data through charts, histograms, cumulative frequency curves, descriptive measures, scatter diagrams, standardization and use of normal curve to compute probabilities, correlation and regression analysis. All these areas are covered in CAST and Manyalla, then a Master of Science (MSc) Applied Statistics student of Maseno University, decided to use CAST in his teaching at KIM after having studied using CAST (Manyalla, 2010).

Mbasu, a second MSc Applied Statistics student of Maseno University, later also used CAST with high school mathematics teachers in Western Kenya, during their in-service training and subsequent follow up workshops. These teachers were introduced to the functionalities of CAST as an instructional resource where much time was spent sharing, discussing and reflecting on how to adapt the resource in their teaching. This was aimed at addressing challenges being faced by both teachers and learners in statistics education which include the lack of quality statistics textbooks and other learning materials. As a result, lesson plans having CAST as a teaching tool were developed for teachers to use. These teachers continue to use CAST with their students when covering statistics topics in the broader school mathematics syllabus.

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This study includes some survey results from the schools use of CAST, but focuses mainly on the KIM study where quantitative data on student performance was collected. Students' performance was recorded for a total of 167 diploma students attending statistics classes in KIM Kisumu branch from March 2008 to June 2010. All students were taught statistics by the same two lecturers and 77 of these students were in classes where CAST was used. In this paper we examine the effect CAST has as a statistics learning resource.

METHOD

CAST has three main components. There is a series of textbooks that include dynamic applets, so the student's reading experience includes interaction and practice (Stirling, 2002). A book of exercises was later introduced (Stirling, 2008) (Stern, Stirling, & Stern, 2009) and each exercise included a random component so that it could be repeated to master the content. A testing system was developed which allowed students to be tested on the exercise (Stern, Stirling, Dale, & Stern, 2010).

A survey was conducted at Chavakali high school, one of the five schools where statistics was taught using CAST. A questionnaire was given to the entire 70 students in form 2 (aged about 17) that were taught using CAST. Data was also collected from the other 4 schools through a short questionnaire to the mathematics teachers. The study at KIM uses data from 2008 to 2010. During this period two teachers were involved in the KIM teaching of statistics in the Kisumu branch in western Kenya. During this period one introduced the use of CAST and the other continued with the traditional teaching practice of lectures together with the use of paper based textbooks. In the last time period described both teachers used CAST.

Students in the class that used CAST worked in pairs on a computer where they completed a series of exercises. CAST exercises were used as an approach to monitor students' learning in relation to identified learning outcomes that required learners to work out exercises which demonstrated their level of statistical conceptual knowledge or skills (Adamson & Darling-Hammond, 2010). The teacher in the class that did not use CAST demonstrated the contents as the students listened and took notes. These students did not use CAST and they completed their assignments without using any computers in class.

The total number of students who participated in the study and used CAST was 77, while 90 did not use CAST. CAST tests were introduced from the second CAST cohort. The tests mirrored a set of exercises that the students had worked on, the questions in the test were identical for all students taking the test in the same hour and a different random version of the questions was used each hour. The students were able to take the test on two different occasions and their best mark was counted towards their continuous assessment Tests (CATs).

Each class had CATs which accounted for 30% of total scores. When CAST tests were used as part of the CAT they only counted as one third of the CAT mark i.e. 10% of the total. The students then sat for a centralized exam that neither of the teachers was involved in setting or marking.

RESULTS AND DISCUSSION

This is the first study on high school and college students in Kenya to investigate the use of CAST. We examined whether CAST can motivate students to learn statistics, whether it can improve performance in the subject and what is it about CAST that works. Our findings indicate that the data focused approach, dynamic graphics, displays and interactivity in CAST motivates students to feel they understand rather than just go through the process.

In one of the schools, a survey about the perceptions of students about CAST was conducted on 70 students. In the questionnaire 100% of students responded that they liked the way they were being taught statistics using computers. There has also been a significant change in attitude towards statistics in the school. Most of the students commented that the resources are relevant to their curriculum, interesting and motivating to use. The use of real life examples enabled them to apply statistical concepts practically. More than half the respondents felt the packages encourage peer teaching and discussion amongst themselves. All the students preferred using CAST exercises to traditional exercises because they were given feedback immediately and were able to practice more by doing many questions. The most interesting result was that 70% of

students suggest that all the topics in the mathematics syllabus be taught using computers and only one student felt that less than four topics should be taught using computers. In an interview about CAST a student says *"I could not understand some concepts because everything was fixed however, we now have some lively electronic resources (CAST) that are interactive and enhances understanding of various concepts taught in statistics"*

The teacher's feedback indicated a desire to move away from the computational aspects of statistics when teaching and focus on developing statistical principles and reasoning amongst learners. In another school, the head of mathematics department says *"I aim at ensuring that teachers and students in the school have access to CAST and use to this helpful resources in teaching statistics topics in Mathematics and Geography"*. Efforts have also been made to spread awareness of CAST through talks and demonstrations to teachers and in other schools.

For the quantitative data collected at KIM, Figure 1 shows the distribution of the students' final marks in the statistics module course for the students that used CAST at KIM and those who did not use CAST.

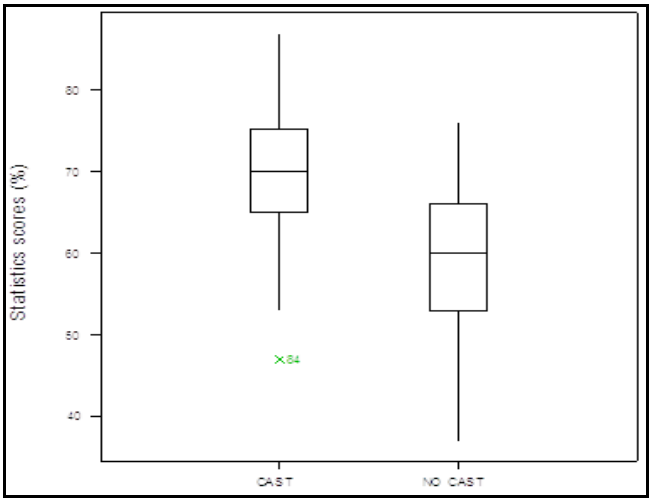

Figure 1. Boxplots showing distribution of students' final marks for the two groups

The first step was to compare overall student performance between the two groups. Most of the students in the classes that used CAST had better scores. The outlier value (x84) scored a 47%, the only one below 50%. This was a special case where the student in the experimental class was absent for many sessions. He also opted to do the other traditional CAT. The mean Statistics score for experimental group was 70% while that for the control group was 59%. Their standard deviations were 7.8% and 8.8% respectively.

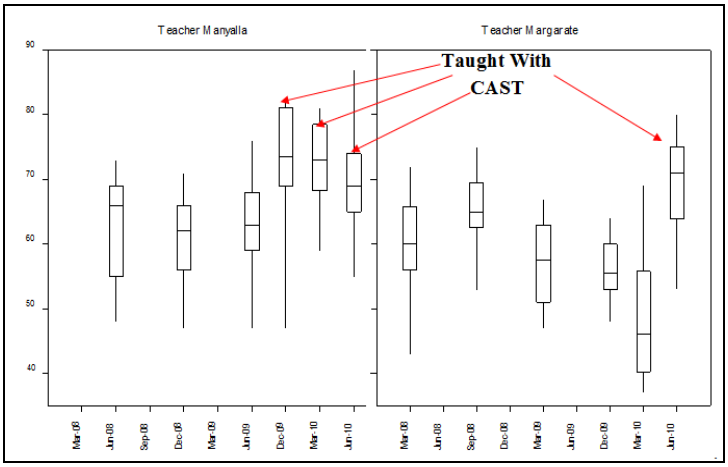

Figure 2. Box plot of students' performance in statistics with or without using CAST

Table 1. Students who did and who did not use CAST over the period of study

	Using CAST		Not using CAST	
Semester	No. of Students	Mean Score	No. of Students	Mean Score
March 2008	0	-	15	59.3
June 2008	0	-	10	62.8
September 2008	0	-	12	65.5
December 2008	0	-	10	61
March 2009	0	-	12	57.1
June 2009	0	-	10	61.6
December 2009	6	71	10	56.1
March 2010	11	71.8	11	48.5
June 2010	60	69.6	0	-

The class that used CAST scored on average 10% higher grades by using CAST, independent of the teacher. This is not surprising because, before sitting for the CATs and subsequent final exam, they had the advantage of trying random questions on the same concept several times using the CAST exercises. After every attempt, CAST gave feedback to tell the student if s/he was correct or not. If not, then the feedback hinted how close the student was to the correct answer. Thus, CAST exercises encouraged mastery of concepts rather than the tortuous effort of just passing a test. Many teachers who are still using the traditional methods of teaching would readily like to provide multiple revision questions to students and mark them in good time. However, their cumulative workload in the institution would not allow them. The automatic and immediate feedback from CAST was welcome to the students.

During the period between March 2008 and June 2009, CAST was not used by both teachers, and the performance of students in the statistics module taught by both teachers was almost the same. Margaret had 39 students, with a mean score of 60.54% in the statistics module with a standard deviation of 7.47 while Manyalla had 30 students with a mean score of 61.80% and standard deviation of 7.74 in the same statistics module which do not differ significantly.

The next stage of study, between October 2009 and December 2009, Margaret taught 10 students traditionally while Manyalla taught six students for the first time using the CAST exercises. While using CAST, relevant topics were chosen from the course syllabus and then CAST exercises were used to consolidate the corresponding concepts. CAST exercises were used as the student's exercises where students practiced with varied random questions. This was very helpful as they would attempt as numerous examples as they needed. When they got wrong answers, they could use the "Tell me button" to get explanation of the correct answer. The students appreciated varied questions that enabled them to master targeted concepts. Dynamic and interactive graphics proved more intense and interesting to sustaining the student's interests as they progressed with their learning. They were also exposed to a number of real life and realistic data which they were likely to encounter in their various fields.

After doing their exam, the mean score for statistics module for the small group that used CAST exercises was 71.00% (SD=5.34) while for the group that didn't use was 56.10% (SD=1.57). Variability in the distribution of the marks among the 6 students, who used CAST exercises during December 2009, can be attributed to one student, who never bothered to use CAST exercises despite numerous attempts to have him attend classes. A two tailed t-test was used to compare the mean score of students taught using CAST to mean of students taught without using CAST. At a significance level of 0.05, there was evidence of statistically significant difference (p=0.037). This was when all six students were included in the class who were given access to CAST. When the student who chose not to use CAST was omitted, the mean for the remaining 5 students was 75.00 (SD=6.4). The difference was now significant at the 0.001 level.

Investigating for the Student Effect on Improved Performance

In March 2010 both teachers had 11 students with one teaching using CAST and the other using the traditional method. In this session CAST tests were used as part of the continuous assessment which ensured that all students engaged with the CAST exercises. The class that used CAST had higher mean 71.52% (SD=6.94) than the class that did not use CAST which had a mean

48.55% (SD=9.91). Performing a standard 2-sample t-test there was very strong evidence ($p \leq 0.001$) with a 95% CI of (15.66, 30.88) of an effect in having used CAST in the teaching of the course. On comparing the average marks for the other five modules when the statistics course was excluded, there was no significant difference in the students' mean mark. This suggests students taught by both teachers had the same ability.

Investigating the Teacher Effect on Improved Performance

It is possible that the different marks for the teacher using CAST, could be from his extra capabilities, due to his MSc training, rather than the effect of CAST. Evidence that this was not the case came from the courses in June 2010 when both instructors used CAST. The students from both groups now took CAST tests as part of their continuous assessment and thereafter sat for the common centralised exam marked by external examiners. Both the exploratory data analysis and a two sample t-test analysis revealed no significant difference in the marks score by the two sets of the students. On comparing the average marks for five modules when Statistics course was excluded, there was no significant difference in students mean mark. When the statistics course was included, both groups showed similar performance.

There was a remarkable performance for both classes even though they were taught by different instructors. The 33 students taught by Margaret had a mean score of 69.85% (SD=8.17) while the 27 taught by Manyalla had a mean of 69.30% (SD=6.85) yielding a pooled mean of $69.55\% \approx 70\%$. The obvious comparison now is with the rest of Kenya, which did not use CAST. The national average was 57% in the statistics module. This national average did include the students from Western Kenya (who had used CAST).

Paper based exercises in Statistics textbooks have always been vital learning aid, assisting students to master statistical concepts. However, they usually contain minimal feedback to students. Many of the limitations of static exercises can be overcome if they are presented and accessed via interactive and dynamic software packages like CAST. CAST exercises have greater potential as a learning resource by providing immediate feedback during exercises. The results of this study suggest that using CAST could be more effective than the theory based lecture approach on improving the teaching and learning of statistics. CAST exercises provide students with the ability to fairly control the sequence of instructional materials, engage their senses, learn interactively at their own pace thereby leading to meaningful learning and consequently, a higher level of achievement than traditional lecture method.

CONCLUSION AND FURTHER WORK

The studies described in this paper were all opportunistic involving teachers and lecturers who were exposed to CAST and convinced that it would help them in their teaching. The results suggest that student motivation and performance are both improved by the adoption of CAST. One could argue that to establish a causal relationship we should have attempted a more formal approach such as an RCT, but we do not believe that RCT's should be considered a gold standard (Cartwright, 2007) and feel that there are many benefits to the approach taken for the KIM study.

Randomizing which students joined which group, as would have been required for an RCT, would not have been practical. It would have interfered with KIM's normal running of the classes and required the lecturers to teach different groups in different ways. This would also have brought very important ethical considerations that we are not deliberately disadvantaging certain students. This was not an issue in our study as the lecturers were always free to teach in the way they felt was most effective. As the study progressed the second lecturer was convinced by the value of the resource and chose to use it in her own way.

A second important aspect is that 'double blind' RCT's , i.e. one in which neither the pupils, nor the teachers are aware which group they are in, allow us to rule out the 'placebo' effect, i.e. the extra enthusiasm of the lecturer in the treated group could have been the cause of the differences in the student's performance. This is usually impossible in educational research as both teachers and students have to be aware of the 'treatment' they are giving/receiving: there are no sugar pills. So it is not possible to rule out the 'placebo' effect, which can be interpreted as CAST increasing teacher enthusiasm and that in turn leading to improved student motivation and results.

As more enthusiastic teachers are also desirable outcomes, the placebo effect does not diminish from the value of the intervention, but it would have implications for scaling out.

Although the KIM study was opportunistic it can be considered as a "Before-After-Control-Impact (BACI)" intervention, that is also popular in environmental research (Manly, 2001). An example might be the application of ecologically sound management to an area of a forest, with one or more control areas being selected, so the effect of the new management could be assessed. The intervention in this study was the introduction of CAST, with its associated exercises and tests. Before the intervention, data was available (from the marks from the two lecturers) to check that the treated and control groups were similar. Further measurements were available, once CAST was introduced, as potential covariates, to check that the change was really due to the intervention. These covariates were the marks from the other five subjects taken by the students in both groups. The impact of introducing computers and CAST was seen to be considerable.

Later in the study, the intervention was also applied to the control area, i.e. the second teacher also adopted CAST for her course. The students in the rest of Kenya now became the effective controls and again there was seen to be a substantial impact.

The KIM study did not totally separate which components of CAST were particularly important, but there was evidence that doing the exercises led to improved grades and the tests ensured that the whole class attempt the exercises. We believe the full benefits of adopting CAST, or a similar resource, are from the "trilogy", i.e. the exercises and tests, as well as the electronic books. Further work is then needed, because the current version of CAST does not have exercises that cover the materials in all the books.

The inquiry into the effectiveness of using CAST in schools and tertiary institutions needs more research and future studies are needed to explore the effect of CAST at different levels. This study is part of ongoing work where CAST and other learning resources are being introduced into schools that have some form of technological facilities. In many tertiary institutions, statistics courses are offered and statistics instructors could be involved in the adoption of CAST and the tests could be included as a part of the continuous assessment component. We still have to develop, investigate and document more about CAST and other statistics resources to enable better statistics learning environments and outcomes across all levels of education.

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