THE USE OF CAST TESTS AND EXERCISES TO IMPROVE THE LEARNING OF STATISTICS AT TERTIARY LEVEL OF EDUCATION

BY

MANYALLA ODHIAMBO BENARD

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DEPARTMENT OF STATISTICS AND ACTUARIAL SCIENCE

MASENO UNIVERSITY

Abstract

Statistics as a course has become a computerised teaching subject due to the changing needs of the students who often use computers to process, and analyse various data sets. Recent technological developments have led to the availability of resources of the highest quality for Statistical teaching, including Computer Assisted Statistics Textbooks (CAST). The purpose of this study was to illustrate the added benefit of using an interactive quantitative method of teaching Statistics over the historical usual classroom teaching at the Kenya Institute of Management (KIM). As part of the objective, this study attempted to conduct educational experiments at different times with different students leading to a quantitative analysis where potential confounding effects are demonstrated and adds rigor to the study using convenient sampling without compromising student's education. This study was conducted at KIM over a period of nine months. Past results on Statistics course obtained by the students taught by researcher(Manyalla) and colleague teacher(Margaret) before CAST usage were compared with results obtained when CAST was used in the teaching of Statistics. A total of 167 students were investigated in this study as having used CAST or not. Out of these, 77 Statistics students were taught using CAST while 90 were taught with the use of the traditional method. An analysis of past Statistics results data showed that the marks were on average about 10% higher than the average marks our students were getting before using CAST. Overall, the average mark for the 90 students who did not use CAST was 59%, and this was close to the national average of 57% in Statistics course. It was just over 70% for the 77 students who used CAST. Future studies are needed to determine the effectiveness of CAST for professional education and training in Statistics department from the various KIM branches and in other institutions where Statistics module is offered.

CHAPTER ONE: INTRODUCTION

1.1 Background information

Statistics has become a computerised teaching subject due to the changing needs of the students. At the same time, many Statistical resources of the highest quality have become freely available for use in Africa including Computer Assisted Statistics Textbooks (CAST) making it possible for the modernization of the teaching of Statistics.

Modernization of Statistical teaching is a continual problem world over. The advances in Statistical methods and tools along with the growing demand of applied practitioners creates a dual need of people with the theoretical knowledge to take the subject further and those with the practical knowledge and skills for the many current problems requiring statistical support (Stern. et al, 2010).

"CAST is a free resource containing many applets that are packaged into introductory and advanced e-books for self learning, exercises, questions from the exercises in a test format and collections of applets for use in lectures" (Stirling , 2010).

This study describes the features of CAST to illustrate its potential uses in the teaching of Statistics with the Kenya Institute of Management, Kisumu branch, as a case study. Statistics is offered in this Institute as a compulsory course. Many Statistics students have regarded this subject with trepidation. Every time the course is offered, many students either withdraw from the course or earn a poor grade. Students cannot retain the Statistical formulae and if they manage to memorize them, they cannot apply them.

CAST resources were used during Statistics lessons over a period of nine months for three different classes spaced at different semesters, with the first group in September to December 2009, the second group in January to March 2010 and the last group in April to June 2010 each taking three months.

The purpose of the study was to investigate the effectiveness of using a new method of teaching Statistics which is computer - based; this objective was achieved by administering CAST tests as part of a continuous assessment test after extensive use of CAST exercises during the lessons. From the findings of this study, it is clearly evident that an effective use of CAST exercises and CAST tests enhanced the performance of students in the Statistics course. Moreover, the use of dynamic and interactive diagrams in teaching helped increase

the student's retention level of the material learnt as compared to the traditional classroom learning approach.

The use of CAST in the teaching of Statistics could ensure sustainability in terms of the availability of free learning resources and also promote good statistical practices within the institute if fully adopted. From the results of this study, the use of CAST provides students with a facility to learn interactively at their own pace while learning statistics.

CAST includes a book of computer-based exercises having random components. An additional CAST resource is the CAST tests that allows for on-line class tests. The tests are identical to those in the exercises but without the button to check the answer or give another version of the question and tests can be easily created as a selection of these questions.

CAST exercises act as a tutor pointing out mistakes and giving suggestions to students who need to improve their knowledge. The use of CAST for educational purposes can help students to learn how to deal with Statistical problems and can increase the certainty of their own knowledge and skills. It also provides a free series of textbooks on Statistics that students can access during or following their training.

1.2 CAST exercises and tests

"CAST includes series of exercises that attempt to maximise the benefit of using an interactive resource to learn key Statistical concepts, as demanded by (McKenzie, 2007). Each exercise is a java applet, like the other dynamic diagrams in CAST, and use of this powerful programming environment, allows great flexibility in the format of questions and the potential for constructive feedback" (Stern et al, 2009).

The traditional format used by colleges and university educators promotes passive learning; students are required to merely listen to and take notes on a lecture, without participating in the lecture (Dabbour ,1997).

A new approach based on the use of computer in teaching Statistics has been experienced in the Department of Statistics at the Kenya Institute of Management, Kisumu branch, for educating students in Statistics. CAST has been extensively used to enhance the traditional way of teaching Statistics through the use of interactive exercises randomly generated. The students were able to choose among various types of exercises and practice beforehand.

With the introduction of CAST the students found themselves doing a lot of hands on activities ranging from drawing diagrams, to making observation on various data sets before

making interpretations. In many instances, the students worked in pairs sharing their ideas together. Each student valued the lesson as they found themselves occupied and actively involved throughout the sessions. The previous passive experience by most of the students from either reading textbooks or listening only to the teacher was completely overtaken by an active and interesting dimension through CAST. Its interactive component sustained student's interest and thereby improved their learning experience (Meyers, 1993).

1.3 Statement of the Problem

A Statistics module is offered as a compulsory subject in KIM at diploma level. Students taking this module have always regarded it with unease. Every time the course is offered, many students either withdraw from the course or perform dismally. As a result, the students end up in other substitute courses which are not in line with their desired careers. There are a few Statistics textbooks in the institute library to be used amongst the students. Many of these Statistics textbooks include a series of exercises at the end of each section or chapter. These textbooks often give solutions to exercises, but these may be as little as a statement, or number. Keeping an up to date library is expensive and most of the students cannot afford to buy recommended textbooks. It is a policy at the institute to examine the students taking the Statistics course. This examination takes the form of work-based assignments and continuous assessment tests. There is a challenge to offer varied tests on given statistical concepts catering for the different classes spread at different sessions such morning class, evening class and weekend classes by the same instructor or different instructors. Some efforts have been made to boost the institute's library through acquisition of computers to supplement the scanty textbooks in stock. However, there is still a long way to go to add more resources to be used in learning and teaching Statistics. CAST could help to alleviate this problem if considered for adoption as a teaching resource.

1.4 Objective of the study

The overall objective of this study was to investigate the use of computer based tests (CAST tests) and exercises in improving the learning of Statistics at tertiary level with KIM, Kisumu branch, as a case study. Specific objectives were to:

1. Investigate for the role of repeated educational experiments in investigating confounding effects.

II. Assess ways of improved methods for conducting educational experiments in a way that is statistically sound

1.5 Significance of the study

The availability of CAST resource freely could ensure sustainability and promote good Statistical practices within the institute in terms of statistical teaching and reliable online testing that will reflect well on the KIM's image of producing students who know how to apply Statistical skills to real-world decision problems and having an immediate competitive edge over both new graduates and experienced employees. The availability of free CAST resources will provide the much needed access to a series of modern Statistics textbooks for many students who may not afford the ordinary paper based Statistics textbooks. The successful use of online CAST tests could be used by many institutions where continuous tests are used as a means of evaluation.

1.6 Outline of the Thesis

Chapter 1 of this study starts with an overview of the main CAST resources, it also include background information on CAST, statement of the problem, study objectives and the significance of the study. Chapter 2 of this study is the literature review. Chapter 3 of this study is the methodology for conducting the educational experiment. In chapter 4, new changes to teaching Statistics at KIM by using CAST exercises and CAST tests are extensively discussed. Chapter 5 provide an analysis of past Statistics exam results for students who either used CAST only or who used CAST exercises and CAST tests compared to those who did not use CAST at all. Finally, chapter 6 encompasses discussions, findings, summaries, conclusions, recommendations and suggestions for further research.

CHAPTER TWO: LITERATURE REVIEW

Increasing attention is being given in education to the process of evaluation whereby the efficiency and effectiveness of teaching and learning are assessed. This has made it necessary for teachers to be more critical of the curricula they teach and the methods they use and to learn how to evaluate their own teaching.

Over the past several years there has been a renewed interest in the understanding and application of Statistics. Students studying Statistics find it difficult to grasp the concepts involved due to the fact that most Statistical problems are word problems requiring a certain amount of reasoning ability, not simply rote memorization. Each problem looks totally different; it is only with practice and experience that students begin to recognize patterns and problem types. In order to develop this recognition, students need to have available a large number of interesting exercises that present the same concepts in different settings

Computers have transformed the subject of Statistics as a whole. Now computers have become a standard tool in teaching applied Statistics courses thereby modernizing Statistical education. Use of this technological approach encourages active learning and fosters better understanding of Statistical concepts (Franklin & Garfield, 2006).

Formative assessment of students through exercises provides valuable information for both teachers and students regarding how well everyone is doing. Exercises provided at the end of each chapter or section of a given topic provides evidence on the basis of which students can be informed of their progress and deficiencies so that they can see where they went wrong in their understanding. Teachers too can determine whether a concept needs to be repeated.

Educators often distinguish between summative assessment where the main aim is to rank students and occasionally compare them to existing standards or norms; and formative assessment that is designed to help students learn the material in a course (Scriven, M., 1967). Formative assessment is given during the process and is carried out simultaneously during the course of instruction. The focus or main aim of doing this is to inform the teacher whether the method he /she use has the desired effect. On the other hand, summative assessment is given at the end of the process and is carried out at the end of the whole units of instruction. This aims at giving information of the overall student achievement and learning. An assessment activity's position on the summative-formative scale depends more on what happens afterwards than its actual content.

Exercises may be presented on computers or be provided at the end of a given chapter as found in most paper-based textbooks. Traditional exercises in the textbooks are commonly used in classroom teaching. The answers to these exercises are quite brief and normally take the form of the correct alphabetical choice in the case of multiple choice questions, or only selected odd-numbered exercises. Where the answer is to be in diagrammatic form, it is normally omitted to save on space in the given textbook. At times no answer is given at all in the main study text but instead a solution guide or study guide has to be bought. There are rarely enough exercises in paper-based textbooks to assist weaker students who may need to repeat similar questions in order to master targeted skills.

In contrast, computer based exercises are much richer in terms of their format which involve multiple choice, numerical answers, interaction with diagrams or a combination of these, possibly in sequence (Stirling et al , 2009)

Statistical courses usually include a continuously assessed component. In most cases the students take them in the form of sit-in tests characterized by a lack of immediate results and an inadequacy of generating multiple test series for a given statistical concept. Since the purpose of tests is to measure student ability, testing needs to be carried out accurately and impartially.

In recent years, new approaches to testing, which are online based, are finding increasing acceptance among educators. For learning language online, free TOEFL tests meant for online study courses and practice provides mainly multiple choice questions. CAST allows for online tests to be taken by the students after having practiced with the CAST exercises. Exercises from CAST are presented as test questions. Immediate results are provided to students as soon as the student finishes the CAST tests. The test can be taken multiple times in order to support students in mastering the material learnt.

Previous use of CAST exercises and CAST tests in Kenya were at Maseno University where a group of MSc Statistics students were successfully able to use CAST to learn Statistics. The students valued the opportunity to take the CAST tests and appreciated getting their results immediately, being shown what was wrong and being able to see the correct answer (Stern et al 2010).

CHAPTER THREE: MATERIALS AND METHODS

3.1 Methodology for conducting educational experiment

Background

Methodology for conducting educational experiment is a well recognised problem due to the potential ethical issues about quality of education one give to students. Many educational experiments have been conducted which support the value of computers in the teaching of Statistics but it is often difficult to obtain data providing good Statistical evidence.

Part of the problem is that random sampling are inappropriate, so convenient sampling is used but this bring many objections due to potential confounding effects. It's far too easy to confuse one cause with another, or to attribute all change to a single cause when many causal factors are operating.

Identifying and eliminating potential confounders is the single most important task faced by researchers. If a confounding variable is allowed to affect the results of a study, no meaningful conclusions can be drawn from the hard work of designing and running the study. Consequently, the vast majority of research design methodology is devoted to this single task. In order to establish true relationship between a cause and the outcome, there is need to take necessary steps to identify and eliminate confounds that may obscure the true relationship with spurious relationship. In this study, the removal of possible bias that might have occurred due to the excellent teacher and good students in the overall student's performance in Statistics exams is demonstrated in chapter 5.

3.2 Procedure

Introducing CAST into KIM

The initiative to introduce an electronic Statistics text book, CAST along with its electronic testing into diploma teaching stems from my previous class work experience while undertaking Msc course at Maseno University. The experience led me to try using CAST in my teaching at KIM. After a formal approval by KIM to teach Statistics using CAST, I started in December 2009 with a small first group of just six students in total. One student did not engage in the exercise, but there was a tremendous progress from the remaining five students.

While I started introducing CAST and exercises to my students, the exercises were being made into a testing system. I was able to observe the teaching and to learn what needed to be done before I could introduce the tests at KIM.

With my next set of students in March 2010, the use of CAST was combined with the 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 teacher who was not using CAST.

With the following intake, examined in June 2010, we (I and my colleague) both used CAST exercises and tests, in an attempt to identify if the change in the students' performance was caused by our improved teaching or the resources. We both taught students of the same level and there was no difference between students' marks in the exams, which was marked centrally, but the marks were on average about 10% higher than the average marks our students were getting before using CAST.

3.3 Research design

The study used a cross sectional survey involving an observation of the Statistics students at the same time, in which two classes were classified according to the method of teaching used, the teacher who taught the class, class time and year/month. The students in the experimental class were taught using CAST while the students in the control class received the traditional instruction. All the students were taught by two experienced Statistics teachers (Manyalla and Margaret) over the period of March 2008 to June 2010. The students are grouped into three categories according to the method of teaching, teacher who taught them, and class time in which they attended the lesson over the period of March 2008 to June 2010. In March 2008 to June 2009 both teachers taught the identical syllabus using the traditional method. CAST exercises were first used by teacher Manyalla (the researcher) in teaching the Statistics course in December 2009 while colleague teacher used the usual traditional method. In March 2010 a CAST test was used as an alternative C.A.T after extensive use of CAST exercises in class by teacher Manyalla while colleague teacher did not use CAST in her teaching. In June 2010 both teachers used CAST exercises during the lessons and there after used CAST tests as part of the continuous assessment. It was not possible to randomize who was in each class; however, further information was available to compare teachers' approaches from previous years when they used identical methods. Information was also available about each student as they took six subjects; one of which was the Statistics module.

Table 1 shows the classification of the students in terms of the teacher who taught them, the Method of teaching used, class time and year/ month attended by the students.

Table 1: Showing the classification of the students according to the method of teaching, teacher and class.

	YEAR	2008				2009				2010		
	MONTH	MAR	JUN	SEP	DEC.	MAR	JUN	SEP	DEC	MAR	JUN	TOTAL
TEACHER MANYALLA	CLASS TIME	-	DAY	-	DAY	-	EVEN.	-	DAY	DAY	DAY	
METHOD OF INSTRUCTION		-	*TRAD.*		*TRAD*		*TRAD.*		*CAST*	*CAST*	*CAST*	
NO. OF STUDENTS		-	10	-	10	-	10	-	06	11	27	74
TEACHER MARGARET	CLASS TIME	SAT.	-	EVEN.	-	SAT.	-	-	EVEN.	SAT.	EVEN.	
METHOD OF INSTRUCTION		*TRAD.*		*TRAD.*		*TRAD.*			*TRAD.*	*TRAD.*	*CAST*	
NO.OF STUDENTS		15	-	12	-	12	-	-	10	11	33	**93**
TOTAL		15	10	12	10	12	10	-	16	22	60	**167**

*Key: TRAD: (*Traditional*), CAST: (Used CAST), EVEN: (Evening), SAT: (Saturday).*

3.4 Variables

The Teaching method used was the independent variable under investigation. The variable influenced by the independent variable was average score in a centralised exam. Two extraneous variables namely; enthusiastic good students and novelty effect of excellent teacher, were investigated in this study as possible confounding effects likely to introduce bias in the overall students performance in DCM 5 centralised exam. The enthusiastic good student's effect were investigated by comparing the average exam marks of the students who

used CAST and those who did not use CAST by first eliminating CAST marks; this is illustrated in section 5.3.4. No participants had previous exposure to CAST. Marks scored by students before CAST usage were analysed to determine whether one class was better than the other on the basis of exam performance, the results showed no significant difference as shown in section 5.3.2. To remove the likely bias due to good (bright) students; exam marks when CAST was first used in December 2009 was compared with and without CAST marks to the marks scored by the class who did not use CAST as shown in section 5.3.3. The results were consistent in March 2010 during which the students who used CAST outperformed those who did not use CAST when CAST marks were included. There was no significant difference in the performance of both classes when CAST marks were removed as shown in section 5.3.4. To control for any bias due to good teacher effect, the researcher compared the results obtained by his students in DCM 5 before CAST usage with results after CAST usage to determine whether the teacher effect determined the overall performance in DCM5. The teacher effect was further investigated when a colleague teacher also used CAST in her teaching in June 2010, where the results indicated that students score in DCM5 after a centralised exam did not differ significantly according to the test conducted; this is demonstrated in section 5.3.5.

3.5 Subjects

The subjects of this study were 167 diploma students attending Statistics classes in KIM Kisumu (management institution) over the period of March 2008 to June 2010. All the participants were in a management education program, having completed a three months prerequisite bridging course in management. The Statistics module is a 4.5 –hour lecture per week. The total number who participated in the experimental class was 77, while the control class comprised of 90 students.

3.6 Material used

KIM as a case study in using CAST exercises

Following the successful use of CAST exercises both in short courses to agricultural researchers, and also for the post graduate Applied Statistics Msc students at Maseno University (Kenya) by Stern. D. of which I was a participant as a student, I found the CAST resource extremely useful in statistical teaching. This prompted me to extend the use of

CAST to the diploma Statistics students at KIM Kisumu branch as a form of teaching Statistics lessons using CAST exercises and tests.

The following topics were covered as part of the regular classroom curriculum in Statistics content for the Kenya Institute of Management: 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. Students in the experimental class received instruction using CAST. The students worked in pairs on a computer where they completed a series of exercises using computer. Students in the control class were instructed using the traditional method. The traditional instruction in this study was lectures given by a teacher, with the use of paper based textbooks. The teacher demonstrated the contents as the students listened. They spent their class time listening and taking down notes. The students did not use CAST and they completed their assignments without using any computers.

CAST with exercises was used for three successive groups of diploma Statistics students at KIM, Kisumu branch. The major use was to check that key concepts that need to be assumed were understood. The problem was usually that students had been taught the ideas, but often through formula, and sometimes without understanding the underlying concepts. This was the first time CAST was used at KIM. The first group were the September/December 2009 semester students who used only CAST with exercises, a second and third cohorts were the January/March 2010 semester and the April/June 2010 semester respectively; these later groups used both CAST with exercises and took the CAST tests.

3.7 CAST exercises which were used at KIM

This section elaborates on the CAST exercises that were used; some parallel comparison is done using the traditional method to establish the effectiveness of the two methods of instruction.

3.7.1 Exercises involving interaction with a diagram

Some CAST exercises require the student to construct or interpret a given statistical diagram as part of question or to use it for comparison purposes. The exercise in Figure 1 asks a student to sketch a cumulative distribution function from information provided in a histogram. The diagram on the right shows the feedback provided while dragging the blue circles on the c.d.f at the class boundaries to adjust its shape .After clicking the 'check'

button, the diagram on the right shows mistakes with the red circles on the c.d.f and yellow shading in the histogram rectangles where the c.d.f does not increase by the correct class proportion. The exercises can be repeated any number of times. Each time a randomization changes the context, the scale on the axis and the shape of the histogram, so the student can practice until they have mastered the concept.

Question.

The histogram below shows the measurements of milk fat content from four herds of 50 cows. Drag the blue dots to draw the cumulative distribution function for the values.

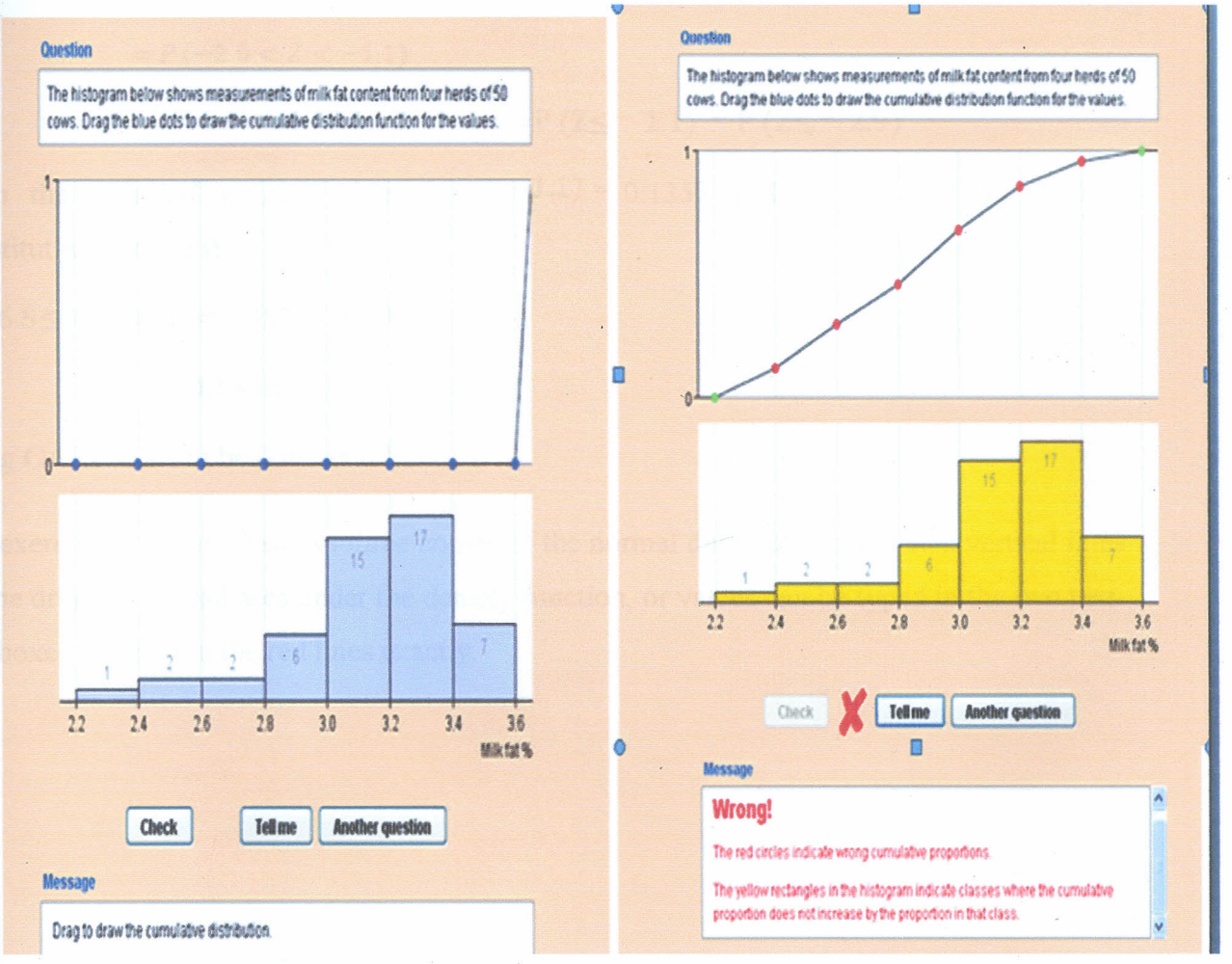

Figure 1: Drawing a diagram

Adapted from CAST 4.0

A second example is a question on the normal distribution solved using the usual method and thereafter done using the CAST approach:

The weight of the seeds of one species of tree has a normal distribution with mean of 21 grams and a standard deviation of 1 gram. What is the probability that one seed from this type of tree has a weight between 18.1 and 19.9grams? Traditionally, the solution to the question is:

$$z = \frac{X - \mu}{\sigma}$$

$$= P(18.1 < X < 19.9)$$

$$= P\left(\frac{18.1 - 21}{1} < \frac{X - 21}{1} < \frac{19.9 - 21}{1}\right)$$

$$= P(-2.9 < Z < -1.1)$$

$$= P(Z \leq -1.1) - P(Z \leq -2.9)$$

From the standard normal table, $P(Z \leq -1.1) = 0.1357$ and $P(Z \leq -2.9) = 0.0019$. Substituting, we see that

$P(16.5 \leq X \leq 18.5) = .1357 \quad .0019$

$= 0.1338$

Using CAST this can be done as follows;

The exercise in Figure 2 shows three copies of the normal distribution. The two vertical lines can be dragged to read area under the density function, or values can be typed in the two text-edit boxes to position the red lines exactly.

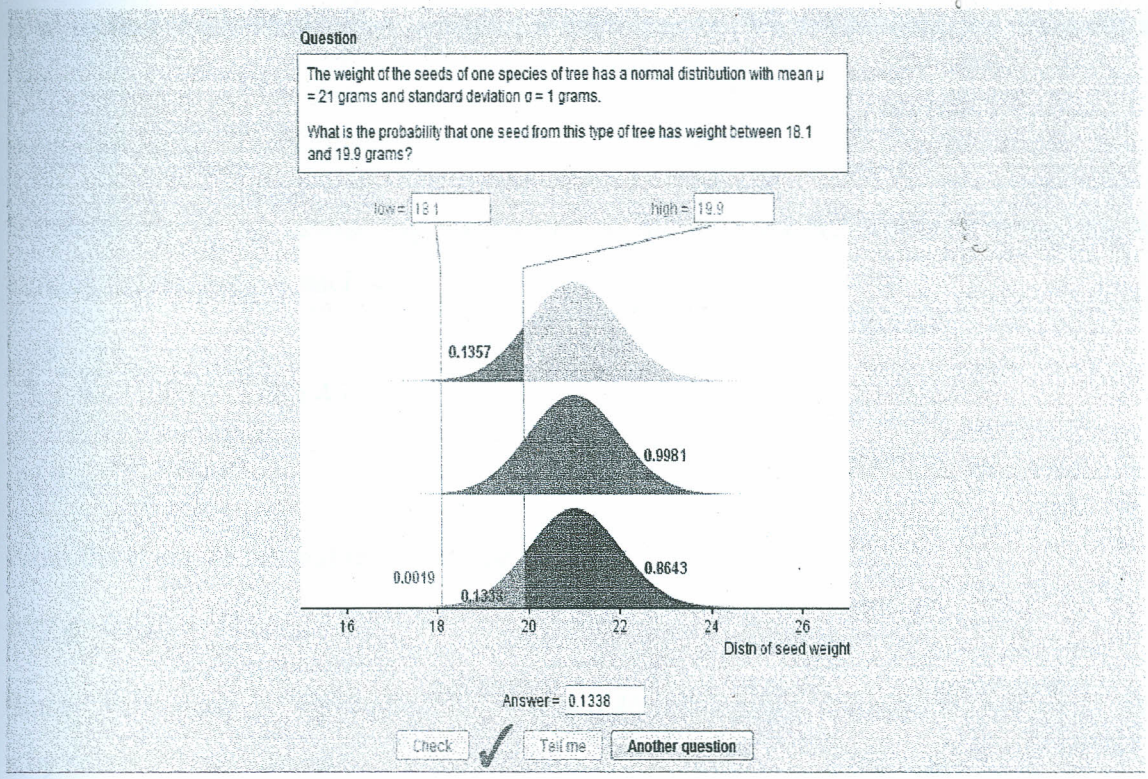

Figure 2: Finding values from diagrams

Adapted from CAST 4.0

In comparison it can be seen that a lot of assumptions have been made to arrive at the answer using the traditional method and the students found it harder to follow through as compared to the method provided by CAST. A number of students had difficult time interpreting the symbols used in the formula. In any case, once the student is bogged down in mundane calculations, he or she pays little attention to the statistical concept and how to interpret results. However, the example in the traditional way does show the process of standardization, which is omitted by the CAST example. That is a benefit of the next example, where you also show tables of the standard normal distribution in CAST. Here is a third example illustrating the old way of solution and then the CAST way;

The maximum daily temperature in a city in January is approximately normally distributed with mean of 25^0C and standard deviation of 4^0C. What is the daily temperature that will be exceeded in 46% of days?

The traditional way of doing this problem is as follows;

This is the type of normal probability distribution problem which involves using the normal distribution tables in the reverse order, that is, we are given a probability, 46% here and we

need to find the normal value to which it corresponds. We are looking for the point x such that

$P(X \leq x) = 0.46$

Standardising X by subtracting its mean and dividing by its standard deviation, we are looking for the point x such that

$$P\left(\frac{X-25}{4} < \frac{x-25}{4}\right) = 0.46$$

$$P\left(Z < \frac{x-25}{4}\right)$$

From the standard normal table, we see that

$P(Z \leq -0.10) = 0.46$

Since -0.10 and $(x-25)/4$ both have area 0.46 to the right, these points are equal. We find x by solving the equation

$$\frac{X-25}{4} = -0.10;$$

Re –arranging gives: $X = 25 + 4(0.10) = 25.4$

Figure3. Shows how the above example is done the CAST way.

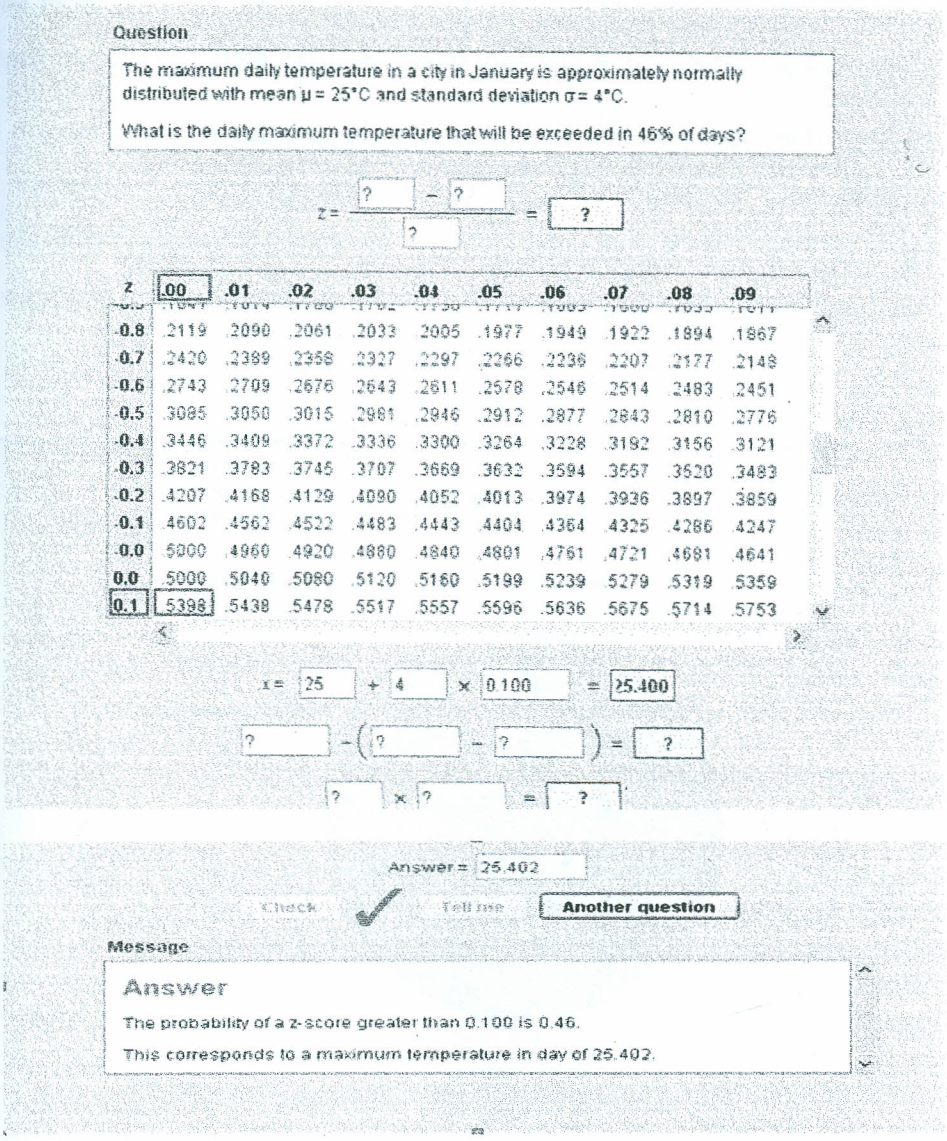

Figure 3: Finding the normal value corresponding to a given probability value;

Adapted from CAST 4.0

In comparison the traditional method seems unclear and much harder to follow as students preferred the first method using computer .Students found it harder to understand the concept of one tail-test needed in solving the problem.

3.7.2 Questions requiring several multiple choices

Figure 4 shows the pie chart of an ordinal categorical data-set and asks for the combined percentage of values in several adjacent categories. The multiple-choice format is sufficient to assess whether students can read the information in a pie chart. Clicking the 'Tell me'

button highlights the relevant pie chart area. As with all exercises in CAST, similar examples can be repeated until the students is sure they have mastered the concepts. Randomization changes the context, data, targeted categories and multiple-choice values.

The procedure of calculating the proportion of the total that each frequency represents and then multiplying each proportion by 360^0 in order to give the sizes of the relevant sectors in degrees requires compilation work which is laborious. Using CAST to draw pie chart makes it more appealing and different shadings or colorings facilitate comparisons.

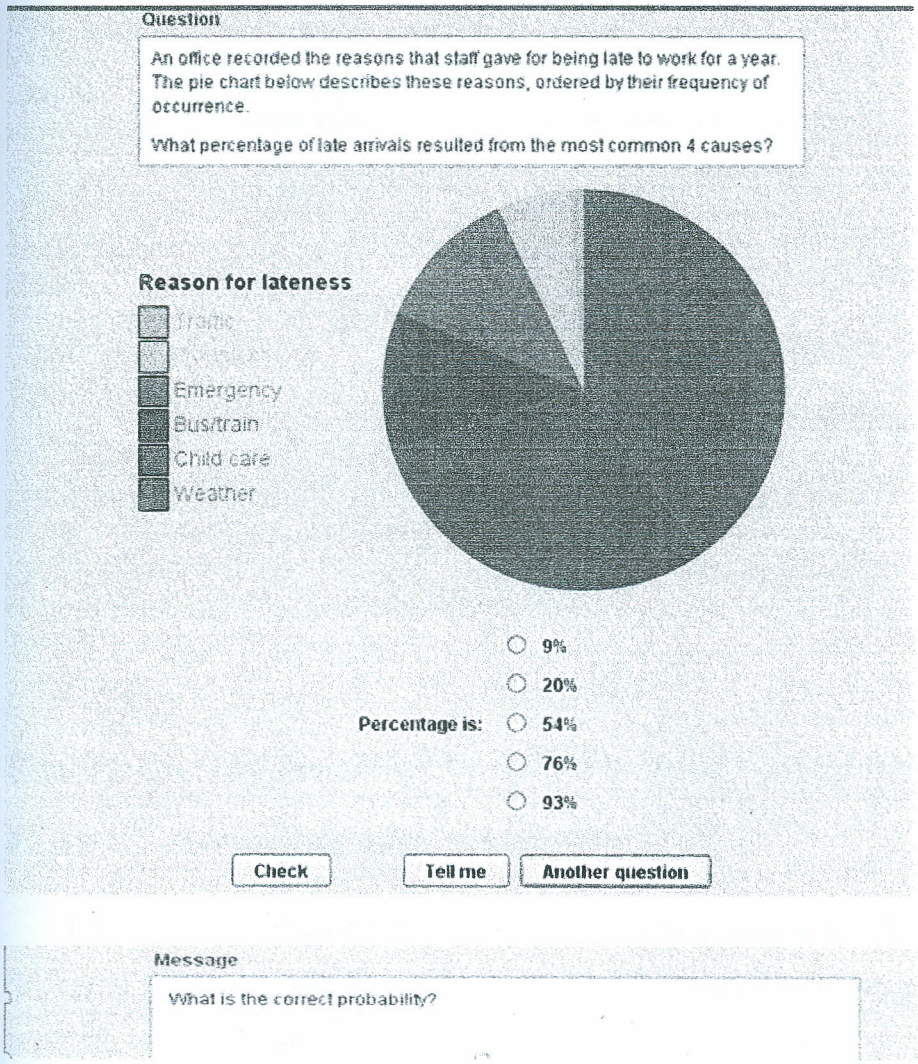

Figure 4: Multiple- choice answers

Adapted from CAST 4.0

3.7.3 Question demanding the use of formulae

The exercise in figure 5 requires the student to do calculations, and a template is provided within the exercise to help with the arithmetic. The student should enter the appropriate values for s/ √n to provide the answer. Figure 5 shows the output after typing the correct answer and clicking the "Check" button.

Question;

The calorie intake was recorded from a sample of n=81 adults in an African village. What is the standard error of the mean calorie intake per person in the village?

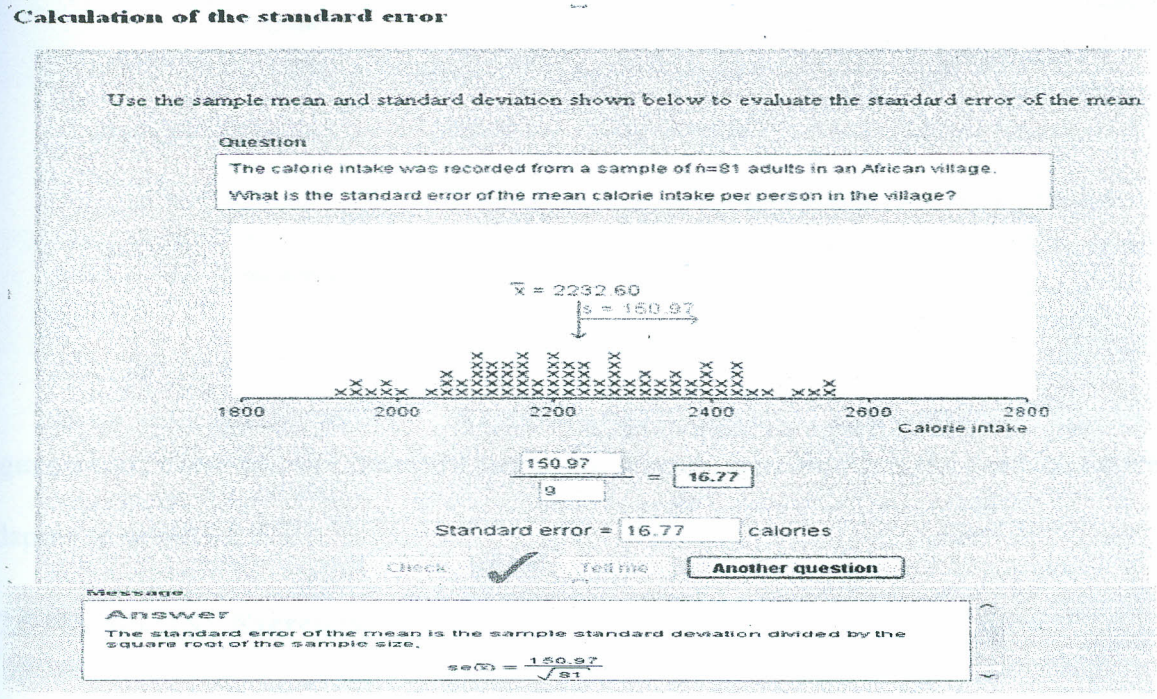

Figure 5: Question demanding the use of a formula; Adapted from CAST 4.0

3.7.4 Exercises requiring numerical answers

The exercise in Figure 6(a) asks the students to guess the standard deviation of a data set 'by eye' from its stacked dot plot while Figure 6 (b) shows the correct answer. A large error is permitted in this guess.

Question; *The following dot plot shows the annual salaries of 46 workers. Guess the standard deviation of the salaries.*

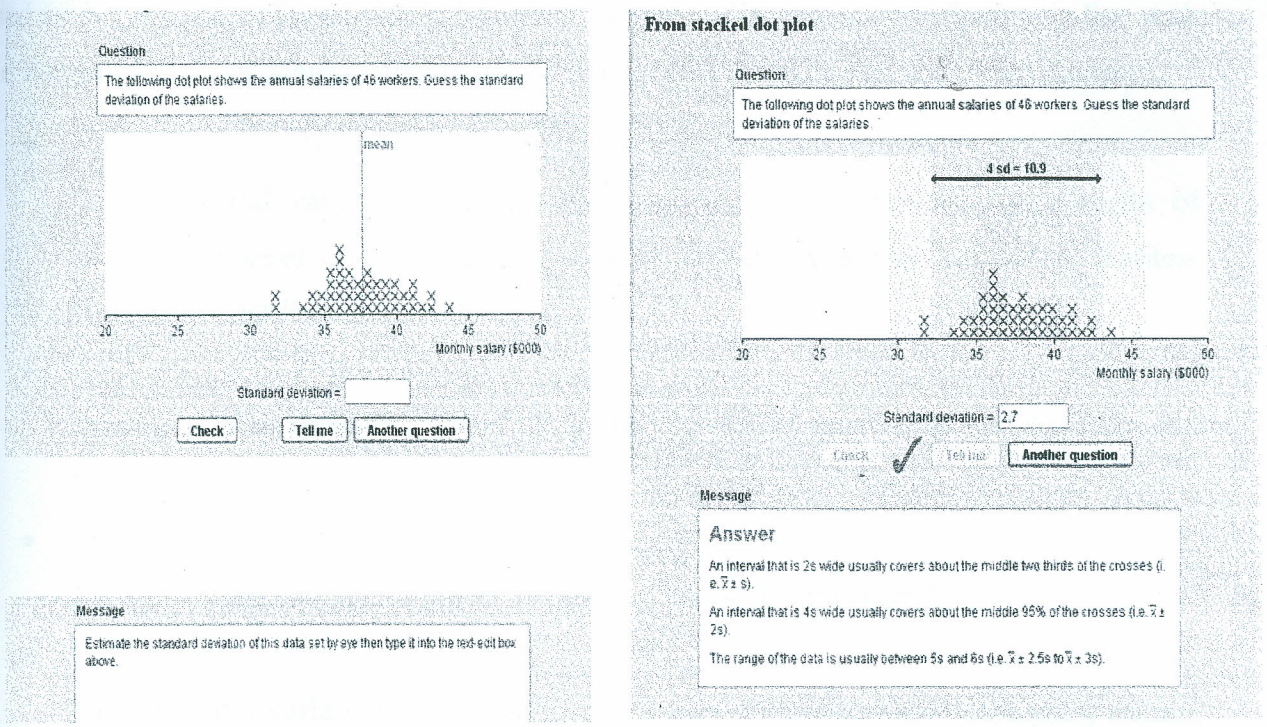

Figure 6 : (a) Guessing the standard deviation; Figure 6(b) showing the correct answer.

Adapted from CAST 4.0

3.7.5 Use of CAST Exercises.

CAST was first used with a group of Diploma students in the October/December 2009 semester. The procedure of administering exercises took the form of choosing the relevant topics as per the course syllabus and then using CAST exercises to consolidate the corresponding concepts. CAST exercises were used as the student's exercises whereby they practiced with varied random questions. This they found helpful as they would attempt as many examples as they needed and get directed feedback each time. Where they got wrong answers, they could also use the "Tell me button" to explain the correct answer.

Students appreciated varied questions that enabled them to master targeted concepts. Dynamic and interactive graphics proved more intense and interesting to sustain student's interests as they progressed with their learning. Students were exposed to a number of real life and realistic data which they are likely to encounter in their various fields.

3.8 Research Instrument

CAST tests aimed at measuring student's understanding on various statistical concepts were used as the instrument for this study. A careful selection of the topics which were in line with the Kenya Institute of Management curriculum was observed. The topics covered included;

- One numerical variable (graphical displays- histograms, numerical summaries of centre and spread- means, medians, standard deviations ,proportion and percentiles- cumulative distribution functions),
- Two numerical variable (scatter plots, the correlation coefficient and least squares lines),
- Categories and counts(frequency tables, bar charts and pie charts),
- Sampling and variability (probability distributions- equally likely outcomes, normal distributions, probability and area under normal curve, finding a normal probability).

Ten test items from CAST were used as C.A.T to measure students' learning of the various statistical concepts covered on the above topics (see appendix 1)

CHAPTER FOUR: IMPLEMENTATION OF CAST TESTS AT KIM, KISUMU.

4.1 Background

Educational testing provides factual information about the student's ability and performance and it enables meaningful comparisons and classification to be made. Neither of these is possible on the basis of subjective assessment arrived at by some vague kind of impression. They can only be achieved by careful and objective measurement using reliable testing standards.

Assessment carried out by carefully planned testing provides a teacher with feedback on his or her own teaching and an accurate assessment of how well each student is doing, where particular weakness and strengths lie, and how the progress of each student relates both to his/her own earlier standards and established norms. It can also provide indication of the student's potential. Without accurate measurement, impressions are bound to be subjective and unreliable. The most common form of testing used in education to assess learning is the examination, since the aim of educational testing is to monitor learners performance, it is perhaps surprising that it has for so long been administered as an end of year testing.

"CAST tests are the latest addition to the set of resources in CAST. They are on-line tests developed to present the CAST exercises as formal test questions. Students can practice before hand with similar randomized exercises and can get immediate feedback as soon as the test is done. The system of testing is separate from CAST. This is in contrast to CAST exercises, which are within the set of structured CAST books. The tests are in two parts. There is an administration module, which is on a server, where the teacher sets up the test, and also includes information such as registration number of students; pin number and subject or course a student is to be assessed on. Students then log on into the server, specify the test they will take and then answer the questions. The test questions are identical to the CAST exercises, except there is no button for "Tell me" or for an "Another question". As soon as a student has finished the test, they may request a review. This gives them mark for each question and also the same feedback as is provided for the corresponding exercises. Because of the extensive random elements associated with each question, the teacher can allow tests to be taken more than once, if that is deemed to be educationally desirable" (Stern et al, 2010).

4.1.1 Use of CAST tests at KIM

The idea to use CAST tests at KIM was proposed after having seen it work with a group of Msc statistics students of Maseno University. I was privileged to take part in the installation of the CAST tests and to take the test as a pilot candidate before the Msc Statistics students did the test. Having seen the extra dimension added by the test, over and above the use of the books and exercises, I extended the idea to KIM Diploma statistics students. This is the first Diploma College to take up the CAST tests.

Courses in Kenya Institute of Management include a continuously assessed component marked out of 30% .The CAST tests were first tried as part of the continuous assessment on eleven KIM Statistics students of the January / March 2010 semester. They were introduced to the CAST exercises in class, where they worked in pairs. Working in pair's facilitated their learning. The students soon found themselves in a cooperative environment and quickly developed more positive attitudes towards Statistics as compared to the traditional environment. Some students proceeded faster than others and therefore did more different types of exercises.

The students completed the exercises in their own time before they took the test. This group took a 10 question test on two occasions and the better mark of the two was taken as part of their "continuous assessment". On both occasions, they took the test at a time of their choosing due to the few computers which had to be used in turn. The test was configured to provide each attempt with a different random version of each question on an hourly basis. The time allowed was forty minutes – which was more than the needed time for the test. An example of a full test done is shown in Appendix 1.

CHAPTER FIVE: RESULTS AND DISCUSSION

5.1 Background

This chapter provides an analysis of past Statistics exam results for students who either used CAST only or who used CAST exercises and CAST tests compared to those who did not use CAST at all.

5.2 Analytical method

Data on past examination results of the 167 students (see appendix 3) were entered into an excel work sheet and thereafter imported into the Genstat third edition (statistical software) for analysis. The data was analyzed descriptively and then by using a two sample un-paired t-test testing for equality of sample variances with an aim of comparing whether the average difference between the experimental class and control class is really significant. F-values were assessed for significance at α =0.05 level of significance. An example of the Genstat output for the period of March 2010 is shown in Table 2

Table 2 showing output from Genstat analysis of the March 2010 result

Two-sample t-test
Variate: DCM5
Group factor: TEACHER

Test for equality of sample variances

Test statistic F = 2.04 on 10 and 10 d.f.

Probability (under null hypothesis of equal variances) = 0.28

Summary

Sample	Size	Mean	Variance	Standard error of mean
MANYALLA	11	71.82	48.16	2.092
MARGARET	11	48.55	98.27	2.989

Difference of means: 23.273
Standard error of difference: 3.649

95% confidence interval for difference in means: (15.66, 30.88)

Test of null hypothesis that means of DCM5 are equal i.e.
(H_0: μ MANY -μ MARG = 0 versus H_1:μ MANY -μ MARG ≠ 0)

Test statistic t = 6.38 on 20 d.f.

Probability < 0.001

Genstat has presented descriptive statistics initially of the variability of the two classes. Experimental and control class averaged 71.82 and 48.55 respectively. Applying the un-paired sample t-test, the class that used CAST exercises scored significantly higher than those who did not use CAST. ($P< 0.001$, 95% confidence interval for the difference in means did not include zero, $t=6.38$, $d.f =20$ $\alpha=0.05$). It can therefore be concluded that the average class achievement of those taught with CAST was significantly higher than those taught without it.

5.3 Results and Discussion

5.3.1 Descriptive analysis of data showing student's performance in DCM5 before and after CAST usage

Before performing any statistical test analysis in the data, an exploration of the data using box plots as shown in Figure 8 was done. The data was plotted using box plots to get a

feel for the difference between the groups. Box-and whisker plots provide a visual summary of five key numbers associated with a data set. These are the smallest observation, the lower hinge, the median, the upper hinge, and the largest observation. Further exploratory analysis of data through scatter graphs was used to illustrate the results distribution on DCM5 versus teaching method used by the teacher and thereafter average score of the students without DCM5 versus teacher.

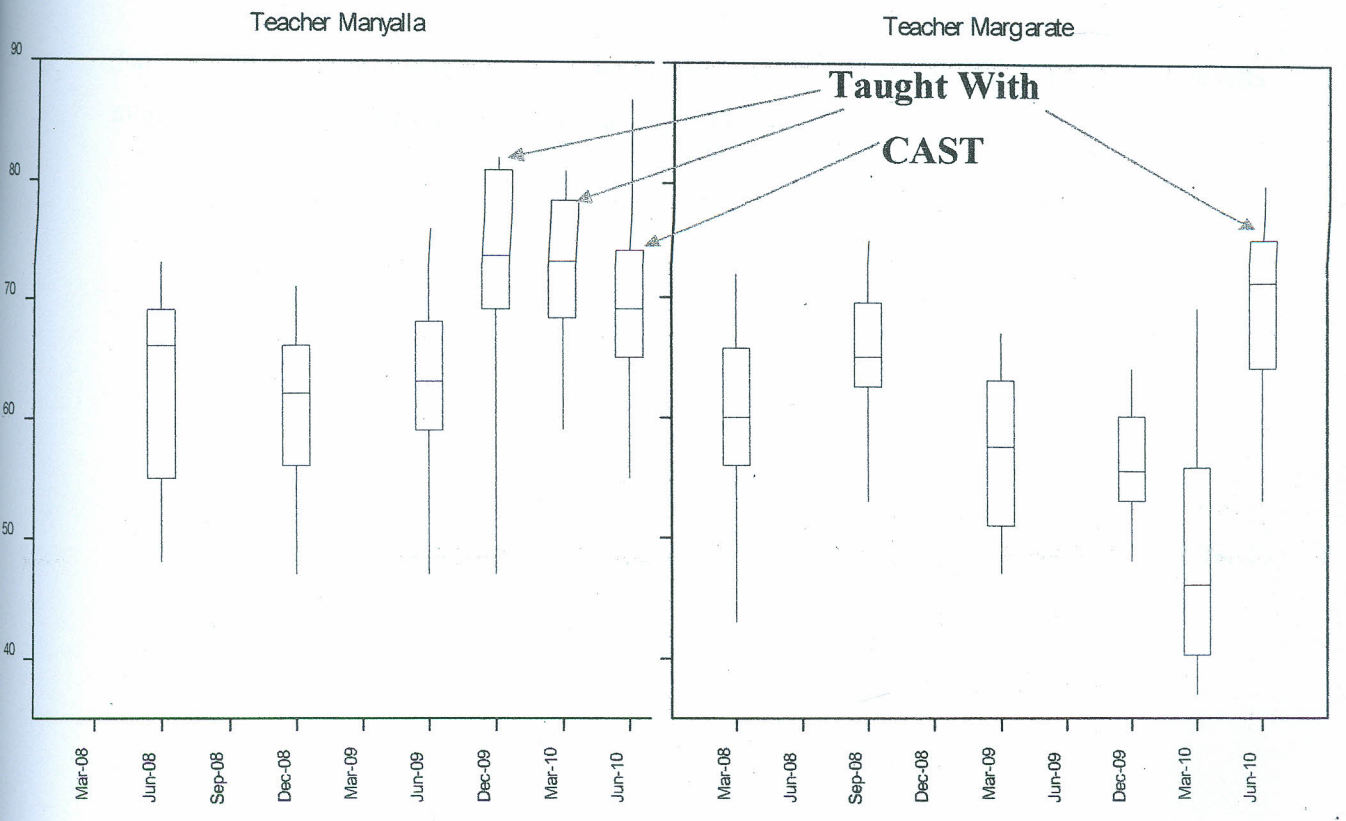

Figure 7 : Box plot of student's performance in DCM5 with or without CAST usage

The distributions of both classes in the period of March 2008 to June 2009 are relatively symmetric and the variances appear to be fairly similar. The overlap in the boxes indicates evidence that during the period of March 2008 to June 2009 the means are not different. By comparing the box plots it is apparent that the distributions of the marks score, after CAST usage suggests that the average was higher than the average for the distribution of marks score before CAST usage by both teachers. In December 2009 when CAST exercises were first used and both classes took the same exam, the experimental class attained higher score on average compared to the control class. However the variability or spread for the distribution of the experimental class was larger than the variation for the distribution of the

control class. In March 2010 when CAST exercises was used together with CAST tests, the distribution in average scores in DCM 5 was approximately symmetrical for the experimental class where as the distribution for the control class depicted slight positive skewness with a higher variability than the experimental class. It means many students from the control class were getting low scores in the test which could be interpreted that either the test was too difficult, or questions were not clear or the teaching method and material used did not bring the desired learning outcomes. In June 2010 when both teachers used CAST, both groups attained higher average score.

Table 3 shows a summary of the two-sample t-test analysis of the examination results attained in DCM 5 over the period of March 2008 to June 2010.

Table 3 Showing a summary of two-sample t-test analysis of examination results attained in DCM5 over the period of March 2008 to June 2010

Exam series	Teacher	Sample size	Mean score	Standard deviation	Difference of means	P-value	95%(CI)
March2008 to June2009	Margaret	39	60.54	7.47	1.262	0.497	(-2.43,4.95)
	Manyalla	30	61.80	7.79			
December 2009	Margaret	10	56.10	1.57	14.900	0.037	(1.22, 28.58)
	Manyalla	6	71.00	5.34			
March 2010	Margaret	11	48.55	9.91	23.27	<0.001	(15.66,30.88)
	Manyalla	11	71.52	6.94			
June 2010	Margaret	33	69.30	6.85	0.549	0.778	(-3.33 ,4.43)
	Manyalla	27	69.85	8.17			

5.3.2 Phase one: When both teachers did not use CAST in teaching

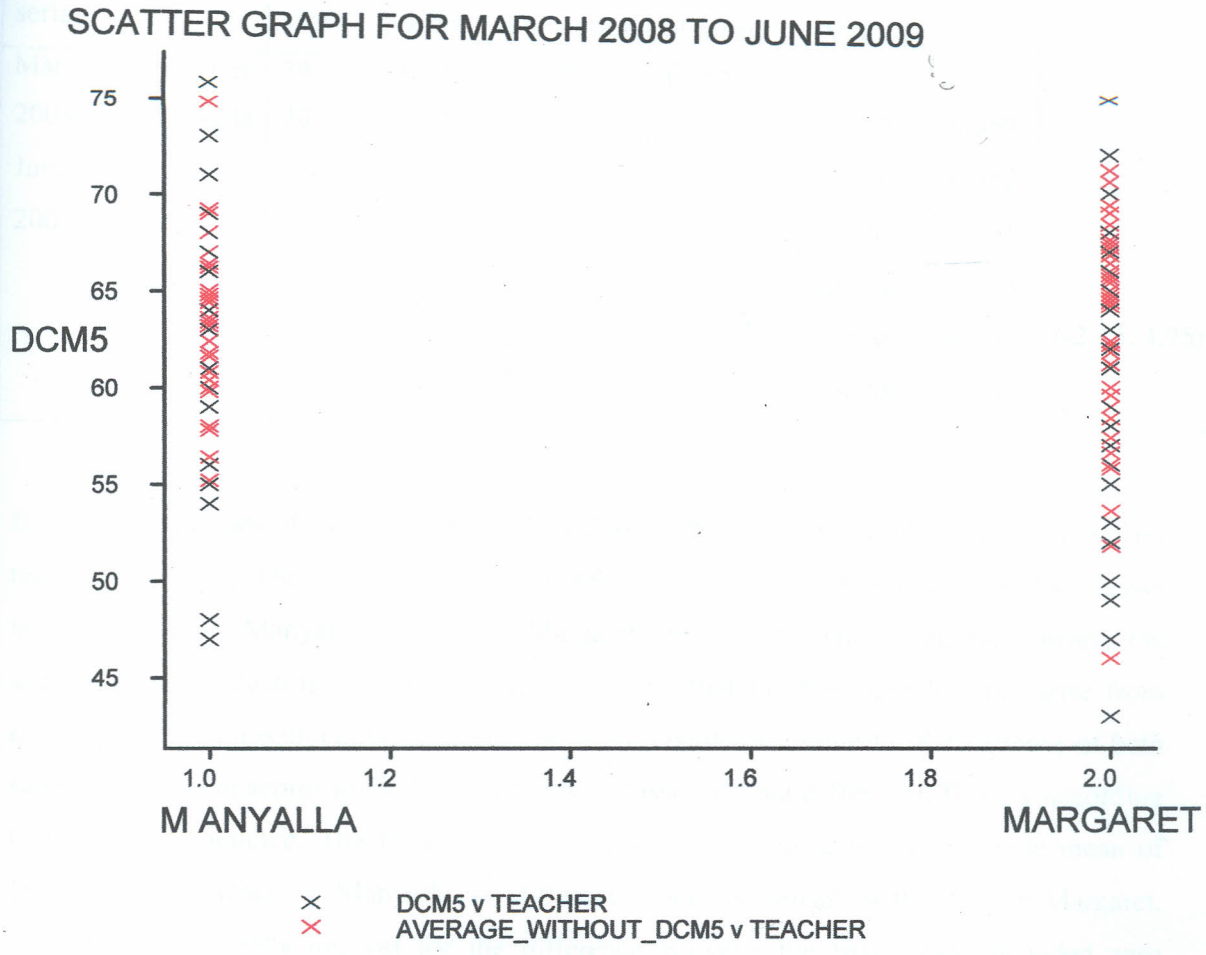

Figure 8: Scatter Graph for results in March 2008 to June 2009

From the scatter graph above, the distribution of scores for both groups were nearly the same and no class outperformed the other. The red crosses show averages when DCM 5 marks were eliminated while the black crosses show the average when DCM5 was included.

During phase one when CAST was not used by both teachers, the descriptive statistics obtained indicated nearly similar performance as per Table 4.

Table 4 Descriptive statistics when CAST was not used both instructors

Exam series	Teacher	Class size	Mean score	Standard deviation	Difference of mean	Course/P-Values		95%(CI)
March 2008 to June 2009	Margaret	39	60.54	7.47	1.262			
	Manyalla	30	61.80	7.74		DCM 1	0.659	
						DCM2	0.982	
						DCM3	0.691	
						DCM4	0.213	
						DCM5	**0.497**	**(-2.43, 4.95)**
						DCM6	0.163	

Between the periods of March 2008 and June 2009 both instructors used the traditional class teaching approach. The mean score before CAST usage were 61.80 and 60.54 for the classes taught by teacher Manyalla and teacher Margaret respectively. The means were nearly the same. After conducting a 2-sample t-test assuming that the two sample sizes arise from normal distribution with equal variances and form a pooled estimate for the variance of both samples, the mean scores in DCM 5 for the two classes did not differ significantly according to the t-test conducted. The P-value of 0.497 gives no evidence that the sample mean of DCM5 with teacher = Manyalla is different from the mean with teacher=Margaret. Equivalently the 95% interval for the difference between the two means included zero showing that a zero difference is consistent with the data at this significance level.

Phase two: When teacher Manyalla first used CAST exercises while teacher Margaret continued with the usual teaching method without CAST

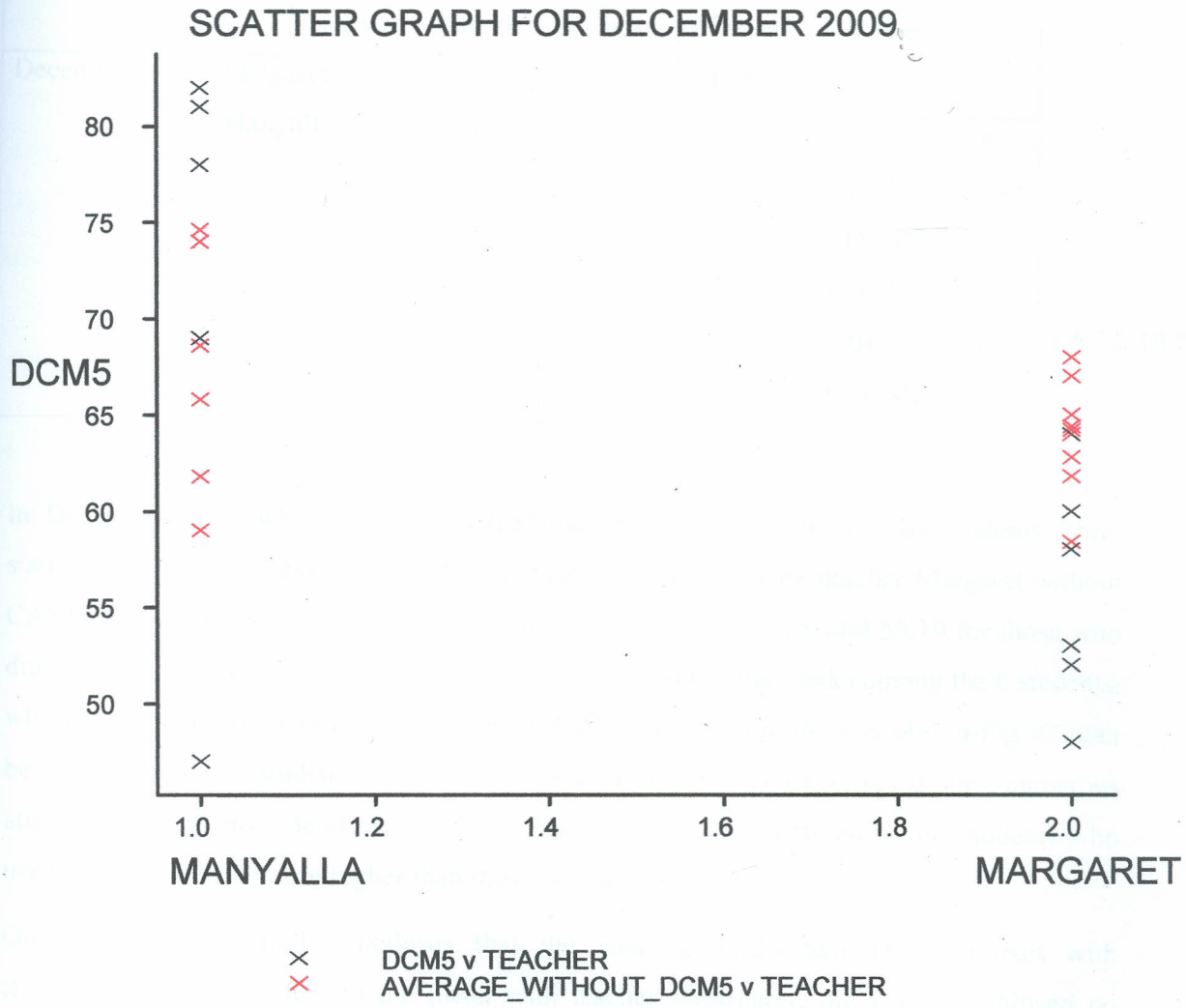

Figure 9: Scatter Graph for results in December 2009

From the scatter graph in figure 10, the students who used CAST had a higher average when CAST marks were included while computing the average score. When CAST marks were removed, both classes got nearly the same average.

Table 5 Descriptive statistics when CAST exercises were used by the experimental class as the control class continued with the usual method of instruction

Exam series	Teacher	Class size	Mean score	Standard deviation	Difference of mean	Course/P-Values		95%(CI)
December2009	Margaret	10	56.10	1.57	14.90			
	Manyalla	06	71.00	5.34		DCM1	0.6	
						DCM2	0.982	
						DCM3	0.691	
						DCM4	0.213	
						DCM5	**0.037**	**(-5.72, 10.59)**
						DCM6	0.533	

In December 2009 when CAST was first used by teacher Manyalla, six students learnt statistics using CAST exercises while ten students were taught by teacher Margaret without CAST. The means were 71.00 for those who used CAST exercises and 56.10 for those who did not use CAST exercises. Variability in the distribution of the marks among the 6 students, who used CAST exercises during December 2009 as reflected in the box plot in Fig. 15, can be attributed to one student, who never bothered to use CAST exercises despite numerous attempts to have him attend classes. From Table 5 the means attained by the students who used CAST exercises were higher than those who did not use CAST.

On testing of the null hypothesis that the mean of individual DCM courses with teacher=Manyalla is equal to the mean with teacher =Margaret, the P-values showed no evidence of rejecting the null hypothesis at the 5% level. However the P-value as reported in Table 3 was small in DCM5 as 0.037 i.e. 3.7% of obtaining a result as extreme as test statistic t=2.68 under the null hypothesis. With this small probability, there is evidence that the sample mean of DCM5 with teacher = Manyalla is different from the mean of DCM5 with teacher= Margaret and as such there is enough evidence to reject the null hypothesis at the 5% level. The average class score of those who used CAST exercises was significantly higher than those taught without CAST. This significance level was when all six students were included in the class who were given access to CAST. When the student who chose not to use it was omitted, the mean for the remaining 5 was 75 with a standard deviation of 6.4. The difference was now significant at the 0.001 i.e. less than the 0.5 % level.

5.3.4 Investigating for the students effect on the improved performance in DCM 5

In March 2010 both teachers presented the same number of students to a common exam, after using totally different teaching methods. The CAST class had higher mean than the lecture only class. On comparing the average marks when Statistics course (DCM5) was excluded, there was no significant difference in students mean mark. But when the DCM5 course was included, there was a significant difference noticed in the average score. It can be argued that, the CAST class did not contain bright students who would do well while the control class contains students who would do poorly. If the students who used CAST were stronger on the whole than those who did not use CAST, we would expect them to do better in the remaining 5 subjects when CAST marks were not included.

Phase 3: When CAST exercises and CAST tests were used in March 2010 by teacher Manyalla while teacher Margaret continued with the usual method without CAST.

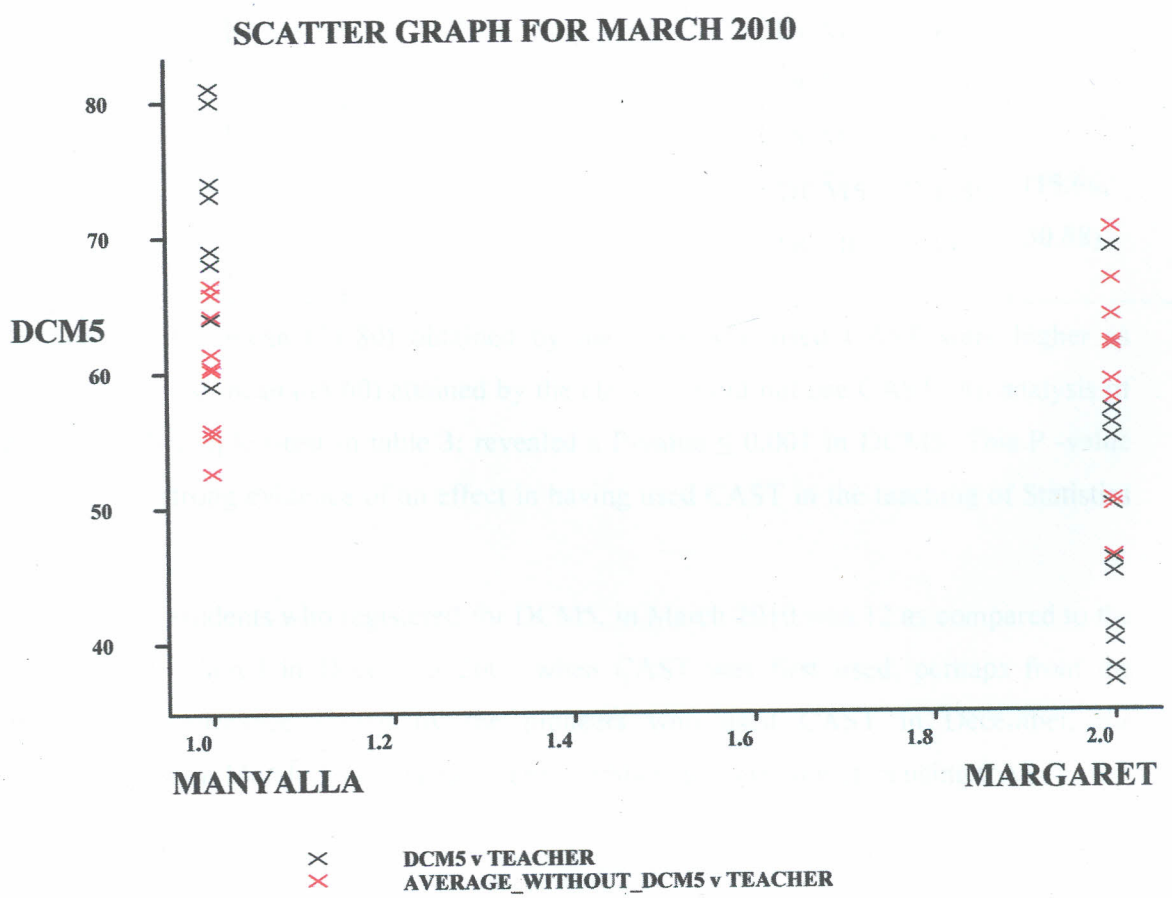

Figure 10: Scatter Graph for results in March 2010

When CAST marks were included, the students who used CAST scored higher compared to those who did not use CAST as shown by the black crosses. After removing the CAST marks, the two classes performed nearly the same on the remaining five subjects as shown by the red crosses.

In March 2010 teacher Manyalla introduced CAST tests after CAST exercises were used during the lessons, while teacher Margaret continued with traditional teaching method.

Table 6 shows the descriptive statistics after end semester exams in March 2010.

Table 6 Descriptive statistics when CAST exercises and CAST tests were used

Exam series	Teacher	Class size	Mean score	Standard deviation	Difference of mean	Course/P-Values		95%(CI)
March	Margaret	11	48.55	9.91	23.27			
2010	Manyalla	11	71.52	6.94		DCM 1	0.010	
						DCM2	0.045	
						DCM3	0.674	
						DCM4	0.873	
						DCM5	**□0.001**	**(15.66,**
						DCM6	0.440	**30.88)**

From table 6, the mean (71.80) obtained by the class who used CAST were higher as compared with the mean (48.60) attained by the class who did not use CAST. An analysis of the standard 2-sample t-test in table 3; revealed a P-value ≤ 0.001 in DCM5. This P -value indicates very strong evidence of an effect in having used CAST in the teaching of Statistics course.

The number of students who registered for DCM5, in March 2010 was 12 as compared to the six students registered in December 2009 when CAST was first used, perhaps from the remarkable performance shown by the pioneers who used CAST in December, the subsequent class in March 2010 rushed in large numbers to learn Statistics using CAST.

5.3.5 Investigating for the teacher effect on the improved students performance in DCM 5

In response to evidence of a possible confounding due to good teacher, a series of repeatable studies was conducted to explore the role of the teacher in the improved performance of the students. To identify the excellent or good teacher effect, both teachers used same method of teaching in June 2010. The students took CAST tests as part of their continuous assessment test and thereafter sat for a common centralised exam marked by external examiners. Both the exploratory data analysis and a two sample t-test analysis conducted revealed no significant difference in the marks score by the two sets of the students.

Phase 4: When CAST exercises and CAST tests were used by both teachers

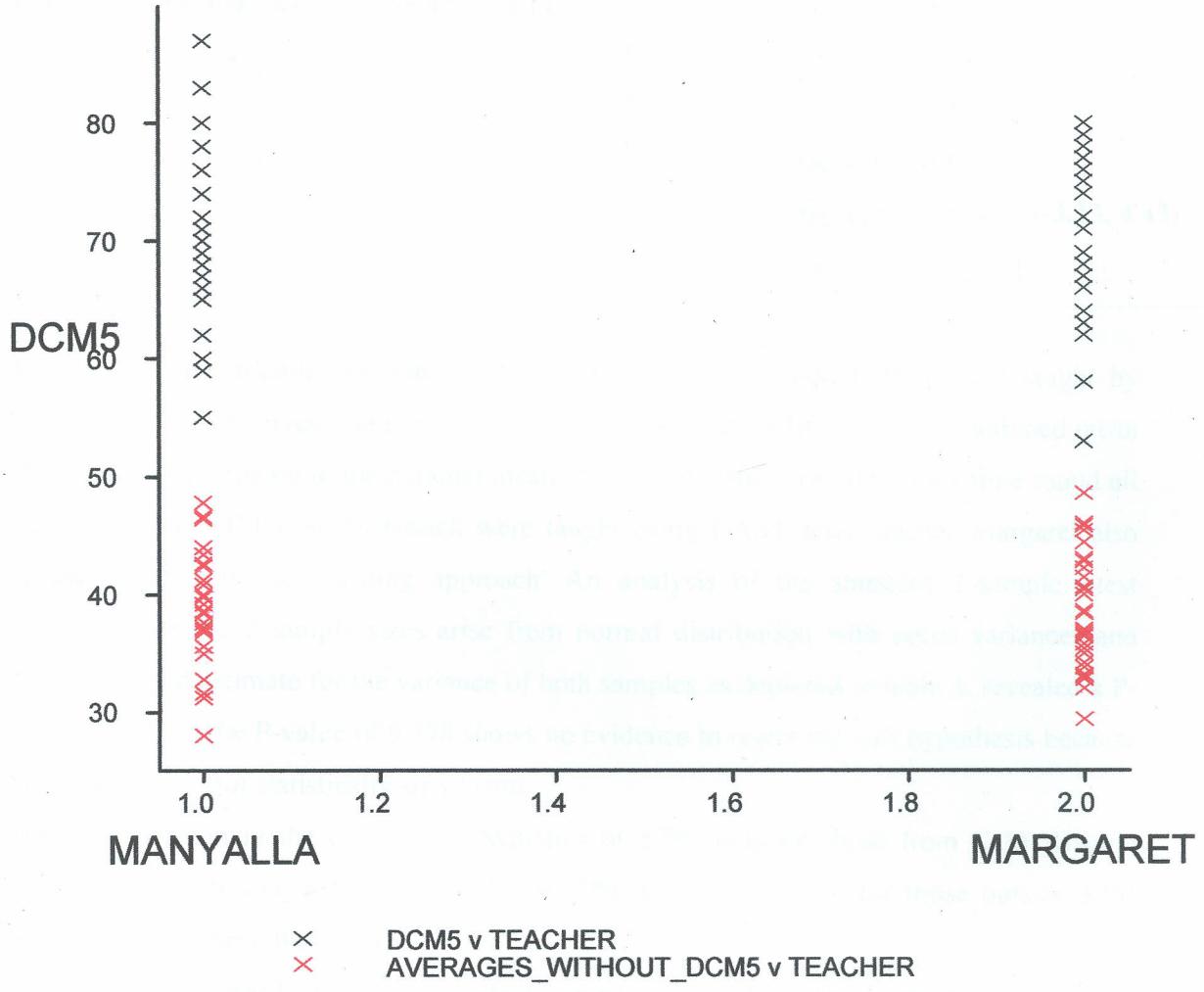

Figure 11: Scatter Graph for results in June 2010

From the scatter graph, the marks were nearly the same when CAST marks were included. After removing CAST marks the classes depicted similar performance.

In June 2010 when both instructors used CAST, there was an improved performance in Statistics centralized examination results. Table 7 shows the descriptive statistics after end semester exams in June 2010.

Table 7 Descriptive statistics when CAST exercises and CAST tests were used by both teachers

Exam series	Teacher	Class size	Mean score	Standard deviation	Difference of mean	Course/P-Values		95%(CI)
June 2010	Margaret	33	69.30	6.85	0.549			
	Manyalla	27	69.85	8.17		DCM 1	0.545	
						DCM2	0.332	
						DCM3	0.282	
						DCM4	0.557	
						DCM5	**0.778**	**(-3.33, 4.43)**
						DCM6	0.225	

There was a remarkable performance for both classes even though they were taught by different instructors given that the mean scores of 69.85 and 69.30 yielding a combined mean of $69.55 \approx 70$ compared to the national mean of 57 in Statistics (DCM5). This time round all the students at KIM Kisumu branch were taught using CAST after teacher Margaret also adopted CAST as the teaching approach. An analysis of the standard 2-sample t-test assuming that the 2 sample sizes arise from normal distribution with equal variances and forms a pooled estimate for the variance of both samples as depicted in table 3, revealed a P-value of 0.778. The P-value of 0.778 shows no evidence to reject the null hypothesis because the difference is not statistically significant.

The overall mean in the country for Statistics of 57% included those from KIM Kisumu branch, where the overall mean was almost 70%. Hence the mean for those outside KIM Kisumu must be less than 57%.

There was an upward increase of students registering to do statistics in that 54 students registered in June 2010. This indicates a remarkable change in the attitude of the students towards Statistics course.

CHAPTER SIX: CONCLUSIONS, RECOMMENDATIONS AND FURTHER WORK

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 weak students. Many of the limitations of static exercises can be overcome if they are presented and accessed via computer.

CAST exercises have greater potential as a learning resource by providing immediate feedback about wrong answers and explanation of the correct answer to students who do not know the correct answer and procedures.

The results of this study suggest that the use of CAST exercises and CAST tests is more effective than the theory based lecture approach on improving the teaching and learning of the statistics syllabus. CAST exercises provides students with the ability to somewhat control the sequence of instructional materials, engage their senses ,learn interactively at their own pace thereby leading to meaningful learning and a higher level of achievement than traditional lecture method.

Courses in many institutions include a continuously assessed component. Where appropriate, the CAST tests could be part of the continuous assessment.

However this study has the following limitations that should be noted. First, a convenience sampling was used in which the participants were not randomly assigned to experimental or control groups. Secondly, this study involved a single institution and lastly this is the first known empirical study conducted using CAST in the Kenya Institute of Management.

Despite the limitations, the findings of this study add to the body of research on the benefits of using CAST exercises with CAST tests. A replication of this study might include more variables such as age, sex of the students and data from other branches of KIM. Future studies are needed to explore the effects of CAST exercises on different grade levels. For scientific research, statistics lecturers at KIM and elsewhere could be involved to adopt this method of instruction. Instructors need to know how the effectiveness of CAST varies with different student learning styles. Future studies are needed to determine the effectiveness of CAST for professional education and training in statistics department from the various KIM branches and in other institutions where statistics module is offered.

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