



## Case Study 7

### Interactive spreadsheets

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## Acronyms and abbreviations

CET	Centre for Educational Technology
OER	Open educational resources
OSS	Open source software
SDU	Schools Development Unit
TISE	Technology Innovations in Statistics Education
UCT	University of Cape Town
VBA	Visual Basic for applications

## Introduction

Students around the world seem to struggle with statistics and consider statistics as 'particularly difficult, as the understanding of the underlying concepts may require more time and energy than for other disciplines' (Härdle, Klinke and Ziegenhagen 2007: 355). Härdle *et al.* reveal how for decades statisticians have endeavoured to find ways to enhance students' understanding of statistics with various technologies from 'relatively simple Excel spreadsheets to integrated learning environments on the basis of HTML and Java' (2007: 362).

This paper describes how the Department of Statistics at the University of Cape Town (UCT) currently uses interactive spreadsheets to assist students in analysing and preparing summaries of data. It explores some of the potential benefits of making such resources more freely available to others as Open Educational Resources (OER), and outlines the key issues which would need to be resolved in order to do so. To this end, this paper discusses the pedagogical needs that led to the lecturers using the spreadsheet program MSEXcel to encourage students to engage actively with statistical processes. It describes how the lecturers and students use these interactive spreadsheets and examines how well these interactive spreadsheets seemed to have worked, so that others who may have similar pedagogical needs can be alerted to the advantages and disadvantages of using this type of technology. In addition, this paper explores the possibility of these interactive spreadsheets being offered as OER first to other departments at UCT and then to a broader community.

## Use of interactive spreadsheets in Statistics Education

Interest in Statistics Education is well recognised (see *Journal of Statistics Education*<sup>1</sup>) and there is a fairly well-established interest area in the use of technology in Statistics Education (see Technology Innovations in Statistics Education (TISE))<sup>2</sup> and a fairly well-developed body of literature (see Mills 2002 for a review of the literature of using computers to teach Statistics). The assumptions made by TISE seem to be fairly representative of the motivation for including technology in Statistics Education:

The editors believe we must teach students to become data scientists who can think about and reason with data. To do this educators must employ a variety of technologies so students can better understand statistical concepts, learn to gain insight from data, and design and shape technology to meet future needs.

Any Google search or a search of more specific OER portals (e.g. Connexions<sup>3</sup>) yields a number of individual lecturers' sites (e.g. Hunt<sup>4</sup>) as well as various group projects (e.g. Lane and Peres 2006). Some materials are available from proprietary companies (e.g. MSEXcel; see Nash 2008) and some are already in the public domain (e.g. Online Statistics,<sup>5</sup> FreeStatistics,<sup>6</sup> Rice Virtual Lab in Statistics<sup>7</sup>). What is not clear is to what extent academics and students are aware of these OER and how they choose to either ignore these options or endeavour to engage with them in the preparation of their own materials for teaching statistics.

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<sup>1</sup> <http://www.amstat.org/PUBLICATIONS/JSE/>

<sup>2</sup> <http://repositories.cdlib.org/uclastat/cts/tise/>

<sup>3</sup> <http://cnx.org/>

<sup>4</sup> <http://www.coventry.ac.uk/ec/~nhunt/home/>

<sup>5</sup> <http://onlinestatbook.com/>

<sup>6</sup> <http://www.freestatistics.info/>

<sup>7</sup> <http://www.onlinestatbook.com/rvls.html>

This paper endeavours to shed some light on this by reporting on the current practices of two UCT Statistics lecturers and their perceptions of their use of digital material to support their teaching and learning activities.

## Background and methodology

### Selection of cases

Selection of these case studies was based on the department's prior application for a Teaching with Technology Grant, offered each year by the Centre for Educational Technology (CET) at UCT, and reported success of their implementation of the funds by the fund co-ordinator in CET. The criteria for the Teaching with Technology grant by implication were embedded in the selection of these case studies. These criteria stipulate that the project should:

- Align with UCT's institutional priorities.
- Comply with UCT's Educational Technology policy.
- Address specific teaching and learning challenges.
- Focus on teaching and learning rather than research (i.e. it may be used to build students' research capacity rather than to support staff research projects).
- Be appropriate for a residential university context.
- Be open to collaborative research.

The criteria also specify that the project should *not*:

- Simply involve the development of a website or buying of a DVD to engage students.
- Simply involve moving content from one learning environment to another.
- Replicate existing tools or services.
- Focus on technical aspects such as computer hardware.

Both Statistics lecturers have received some support from the Teaching with Technology grant offered by CET and both have, on more than one occasion, presented their work with interactive spreadsheets to the UCT community through public seminars. It is for this reason that they were selected as the focus of this case study. In addition the materials have a potentially high 'shareability',<sup>8</sup> as the discipline of Statistics is fairly universal, even though local examples help students grasp concepts more easily.

### Case study methodology

This study adopted the case study as a methodology, which Robson defines as 'a strategy for doing research which involves an empirical investigation of a particular contemporary phenomenon in its real life context using multiple sources of evidence' (1993: 52). A range of methods were used to investigate the use of interactive spreadsheets by the Department of Statistics. These included presentation and document analysis; and follow-up interviews and meetings with both lecturers.

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<sup>8</sup> 'Shareability' means 'that it should be easy to the users to share their obtained results in order to propagate their searches to other users with similar interests or, on the other hand, to other repositories which might have additional contents related to the topic of interest'.

([http://www.olcos.org/cms/upload/docs/Share-OER\\_en.pdf](http://www.olcos.org/cms/upload/docs/Share-OER_en.pdf))

## Case study: Interactive spreadsheets by the Department of Statistics

### Contextual challenges

During the interviews, one of the lecturers explained that South Africa needs a far more coherent view of Statistics from school level through to University level. Students coming to UCT are ill-prepared for Statistics and consequently lecturers need to accommodate this by trying to scaffold the learning of Statistics for about 2000 first year students. Given the numbers of students, both lecturers explained how they have tried to introduce innovative teaching methods to accommodate many of the students' poorly developed mathematical and statistical knowledge and skills.

However, they also highlighted an additional contextual constraint at UCT – the predominance of the 'culture of research', which reduces the focus on teaching. One of the lecturers referred to UCT's 'culture of research' as a 'selfish paradigm' and suggested that UCT is 'losing sight of its role in providing access to knowledge' and thereby 'ignoring its responsibility of the development and dissemination of knowledge in response to societal needs'. He was quick to explain that, while individual leaders are enthusiastic about teaching, the 'structures at UCT often mitigate (sic) against addressing societal needs more directly'. He acknowledges that while UCT has certain structures in place, such as the Schools Development Unit (SDU), that endeavour to address the university-school divide, these structures are not central to UCT. He reflects that even though SDU has a team of dedicated people who are intent on 'making a difference', due to the constraints with which they have to contend he feels they are perceived as a 'Cinderella department' at UCT.

### Pedagogical problems

Apart from the ill-preparedness of students and their sheer numbers, lecturers have to contend with a heterogeneous group of students, which makes lectures particularly challenging, as lecturers tend to pitch the lecture at the 'median student'. This means that the lecturer has to find ways to challenge the top 10%, while continually assessing the weakest students to judge whether they are keeping up or not. Another pedagogical constraint identified by one lecturer is the variable levels of computer literacy among first-year students in particular. Statistics requires a high level of computer skill and many students do not display the computer literacy and skills required.

A further pedagogical constraint is that Statistics courses are taken by students from a range of disciplines. As their webpage elaborates:

The Department of Statistical Sciences at UCT is responsible within the University for the development of the Statistical Sciences which are, inter alia, the disciplines variously known as Statistics (and all sub-disciplines such as Biostatistics, Biometrics, Econometrics, Technometrics), Operations Research, Management Science, Quantitative Methods, Decision Science and Quality Management, and for the application of the Statistical Sciences in all areas of human endeavour. The Department of Statistical Sciences is located in both the Faculty of Commerce and the Faculty of Science. In the Faculty of Science it forms part of the School of Mathematical Sciences, along with the mathematics and applied mathematics department and the computer science department.<sup>9</sup>

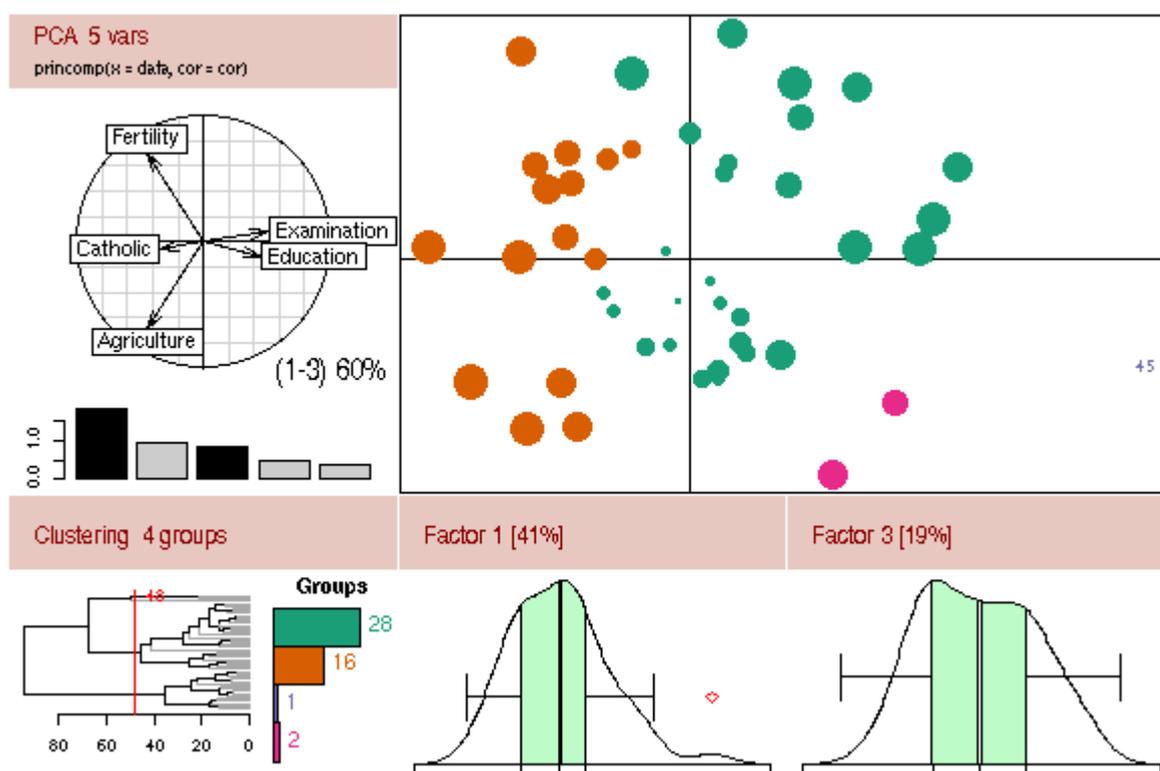
The consequence of this multidisciplinary responsibility is that lecturers constantly have to adapt their statistical examples to a particular discipline.

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<sup>9</sup> <http://www.science.uct.ac.za/departments/stats/>

## Development of interactive spreadsheets

In response to the contextual and pedagogical challenges detailed above, the lecturers have developed a range of innovative teaching strategies which include the use of online games (e.g. Casino Roboto,<sup>10</sup> see Durbach & Barr 2008) and a range of proprietary software (e.g. Visual Basic,<sup>11</sup> see Barr and Scott 2008; Autograph<sup>12</sup>). They have also developed a range of innovative teaching materials, including interactive tutorials and exercises in MSExcel, banks of multiple choice questions and using 'R', a free software environment for statistical computing and graphics<sup>13</sup> (Figure 1).



**Figure 1: The R Project for Statistical Computing<sup>14</sup>**

One lecturer also developed a single data resource for all students in order to particularise the MSExcel tutorials and practicals by random designation of data start and end points for each. This means each student has a unique tutorial and cannot simply copy from another student. Both lecturers are willing to share their materials, but have slightly different ideas of how this may be done.

10 <http://www.battlelinegames.com/>

11 <http://msdn.microsoft.com/en-us/vbasic/default.aspx>

12 <http://www.autograph-maths.com/>

13 <http://www.r-project.org/>

14 <http://www.r-project.org/>

The other lecturer has almost completed writing a suite of software modules for use primarily in the teaching of first- and second-year statistics modules. These are currently being used in STA1000 at UCT and have been used in second-year courses since June 2005. The modules are written in VBA (Visual Basic for applications) which is built into MSEXcel. These modules demonstrate, with strong use of graphics, basic statistical concepts, by using simulation and they have improved the effectiveness of the teaching of Statistics at UCT. For instance, by simulating over 1000 replications one can demonstrate the acceptance or rejection of some null hypothesis, given some (selected) underlying distribution. This can then be used to demonstrate, for example, the concept of the power of a test using actual data rather than the normal theoretical exposition.

The lecturers use interactive MSEXcel spreadsheets to teach often elusive concepts in Statistics such as random variation, sample mean, central limit theorem and statistical significance. They are convinced that the spreadsheets help to equip students to apply these concepts and they also suggest that the level of questioning in class indicates possible new student insights.

### Interactive spreadsheets as possible OER

From his funding proposal to CET in 2005 it is evident that one of the lecturers had the sharing of materials in mind when he wrote: 'we hope to be part of a sharing of items across universities so that we all obtain a bigger pool'. The other lecturer had thought of making his MSEXcel exercises available as an online book, such as those from the open access publisher, HSRC Press.<sup>15</sup> A further idea from the former lecturer is to migrate all his MSEXcel resources into the open source spreadsheet CALC. He strongly supports the idea of using open source software (OSS) such as CALC (such as that in the Shuttleworth-supported Open Lab at UCT), but he does not recommend encouraging the use of CALC only. While wanting to promote fluidity between MSEXcel and CALC, he notes that CALC needs to become more powerful to compete in a market that demands the use of MSEXcel. He hopes that some benefactor could be found to diagnose the weaknesses of CALC and develop it so that it could even supersede MSEXcel.

One lecturer felt that it would be worthwhile to find a benefactor to sponsor the development of South African Statistics materials that could be used by all universities in the country and properly evaluated from the inception of their use. Versions of these materials could be developed for the various disciplines. He was very keen to work with 'wild thinkers' to map out these ideas intellectually and financially.

### Lessons learned

There are a number of useful lessons to be gleaned from this case study.

#### The predominance of MSEXcel

While at least one Statistics lecturer is keen to use the open source spreadsheet CALC, as this still needs quite a bit of development (See Wikipedia entry for discussion<sup>16</sup>), employers still require mastery of MSEXcel. This is a project way beyond the Department of Statistics at UCT, it is worth noting. If CALC were equivalent to MSEXcel, at least one Statistics lecturer would be prepared to migrate his MSEXcel exercises and tutorials to CALC.

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<sup>15</sup> <http://www.hsrcpress.ac.za/>

<sup>16</sup> [http://en.wikipedia.org/wiki/OpenOffice.org\\_Calc](http://en.wikipedia.org/wiki/OpenOffice.org_Calc)

## Grants required for scaling up

While there is a fairly substantial set of resources in MSEXcel, further grants would be required to create versions for the different disciplines.

## Survey needed of student use of Statistics OER

As there are a number of Statistics OER already available, it would be valuable to assess to what extent UCT students are using these; if they are, what they find most useful; and, if not, what they *would* find most useful.

## Conclusion

Statistics lecturers at UCT are faced with very large classes of variously prepared students from a range of disciplines. They have responded to this challenge by using a range of innovative teaching materials, specifically interactive spreadsheets in MSEXcel. In principle they are keen to share their materials, but would need some technical support to do so. What is not clear yet is to what extent these materials are similar to those already available as OER or to what extent students are already making use of OER in Statistics to support their learning. Further investigation is required.

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