THE DEVELOPMENT OF ONLINE NUMERACY MODULES FOR FIRST YEAR UNDERGRADUATE STUDENTS AT AN AUSTRALIAN UNIVERSITY

Marian Kemp
Murdoch University
90 South Street, Murdoch, WA, Australia 6150
m.kemp@murdoch.edu.au

Introduction

An essential part of being a critical reader at university, and as a citizen, is the ability to interpret quantitative material in a range of contexts (Gal, 2002; Kemp, 2005, 2009; Steen, 1997, 1999; Watson, 2006). This includes the disposition to engage with the material, an awareness of the ways in which numbers are employed to convince, persuade and justify, some appreciation of the ways in which data is collected and collated making it more or less reliable, and the ability to interpret tables, graphs and charts. It is a challenge for educational institutions at all levels to provide appropriate curricula to engage students in activities to foster critical thinking about quantitative information.

In Australia most of the universities are public ones, funded by the Federal Government, but there is an increasing number of private providers of diplomas and degrees. Currently the higher education sector is responding to the recommendations of the Bradley Review (2008) that advocates that 40% of people in the 25 to 34 year old age group will have bachelor-level qualifications by 2020. To achieve this goal institutions need to admit more students from non-traditional and more diverse backgrounds into programs of study. Indeed, universities are providing more alternative pathways for a range of students through enabling programs, bridging programs, special entry tests and secondary school programs. These programs target Equity groups including Low SES students, mature aged students and school leavers with disrupted educational backgrounds.

Associated with this increase in diverse pathways progressively more students will be underprepared for the critical reading required for university study. Murdoch University has taken seriously the need to prepare students for university study and expectations related to academic literacy, numeracy and study skills. For over twenty years Foundation Units, which are mandatory for all first year students at Murdoch University, have provided an interdisciplinary introduction to university study. A unit of study in the first year is one-eighth of a full year load. Students can choose from seven units, with themes such as *Wellbeing*, *Australia in Asia, Creativity and Innovation* and *Food for Thought,* that aim to help students consider local, national and international issues from different perspectives. All Foundation Units focus on the development of the academic skills that students need to succeed at university, convened through the Student Learning Centre. Students also learn about the expectations of universities with respect to the academic essay and report writing, referencing and citing, critical thinking and critical

reading, as well as the practical aspects of time management, note-taking and using the Learning Management System.

The Foundation Units include the explicit development of quantitative interpretation skills in the context of critical reading through focussed tutorials. Murdoch students include approximately 35% of students straight from school, and mature-aged students who enter through a range of pathways. Over the last ten years it has been found that increasingly students are hindered by their weak mathematical backgrounds and their inability to apply appropriate concepts and skills to their critical reading. At Murdoch University students are not required to take a unit in mathematics unless they are in particular science-based programs, and there is no mathematics prerequisite for University entrance. To respond to this issue the Murdoch University's Student Learning Centre has developed a set of online modules that help students to develop a range of mathematical and statistical concepts and skills to assist their critical interpretation of quantitative aspects of print and online materials. These are available to all students enrolled in the Foundation Units, and some other units where requested by the unit coordinator.

Murdoch University provides flexible learning environments for its students. They can study internally and externally with resources provided through a Learning Management System. Given the nature of students and the way they currently interact in their everyday lives with online materials (Thomas-Jones, 2010) it was deemed most appropriate to provide *Numeracy Modules* in an online mode, rather than supplementing a set of self-instructional worksheets that already exist on the Student Learning Centre website. The fundamental issue for the Student Learning Centre was on the question of how to design and use effective ways of presenting such online modules.

The author and Bruce Hilliard, a colleague in the Student Learning Centre, decided that the mode of module delivery would be through animated *PowerPoint* presentations to be accessed by students through the University Learning Management System (LMS). Each module would be viewed by the student by using the forward and back keys on the keyboard so students move through at their own pace. Hilliard is enrolled in a PhD focussing on perception from a cognitive perspective and he would analyse the data from the project as part of his research. Almost all of the students can download *PowerPoint* presentations and as such the technology is accessible to the first year students. The choice of *PowerPoint* for the modules was influenced by the literature which indicates that *PowerPoint* "has the highest value regarding learning and motivation" (Tang & Austin, 2009, p.1251) and can "contribute to teaching effectiveness" (p.1252) as well as enhancing a student's "ability to remember, understand apply, analyse, evaluate and create information" (p.1253) which "may lead to the highest amount of learning and understanding".

The modules

The rationale underpinning the modules was the identified need to enable students to become more effective critical readers and thinkers. The weak mathematical backgrounds of some of the students hampered this development. The content of the

modules was carefully selected and developed to support students in their university study and to encourage critical thinking longer term.

Table 1. The Numeracy Modules

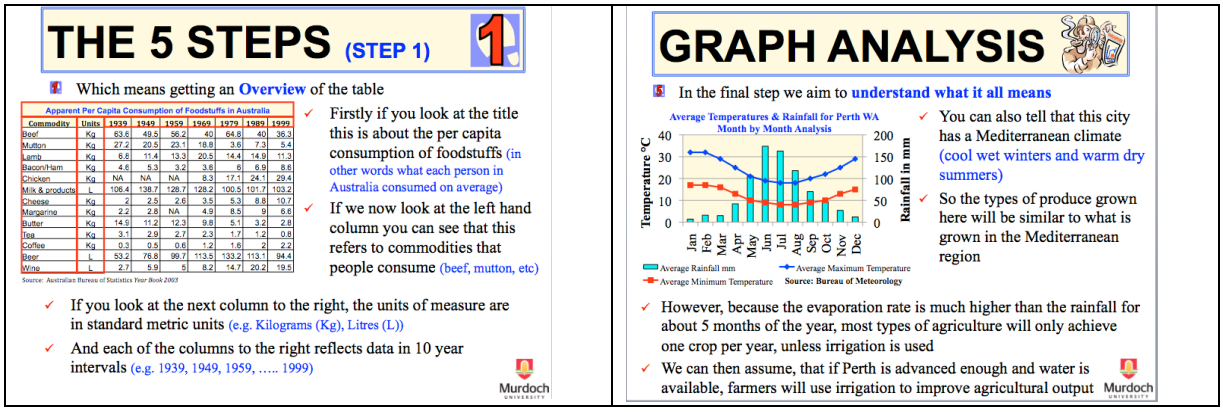
Module 1 - Decimals & Percentages	Module 10 - Probability - Using the Analytical Method
Module 2 - Scientific Notation	Module 11 - Probability - Using the Empirical Method
Module 3 - Introduction to Fractions	Module 12 - Understanding Sampling
Module 4 - Proportions & Ratios	Module 13 - Non-Sampling Errors
Module 5 - Units of Measurement	Module 14 - Causes for Errors: Analysing the Methodology
Module 6 - Mean, Median & Mode	Module 15 - Understanding Variation
Module 7 - Using Tables	Module 16 - Variation - Applying Standard Deviation
Module 8 - Understanding Graphs	Module 17 - Working out Standard Deviation
Module 9 - Understanding Probability	

The first six modules reviewed school mathematics normally studied at elementary or lower secondary school levels. Modules 7 and 8 introduce a Five-Step Framework (Kemp, 2005) designed to help students unpack tables and graphs from a perspective not normally used in school mathematics. This is outlined in Table 2.

Table 2. Five Step Framework

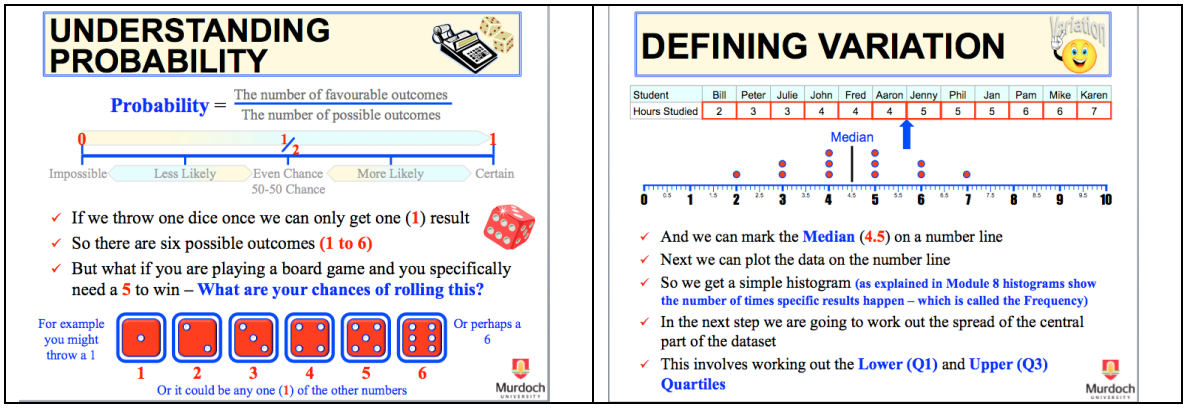
Step 1: Getting started
Look at the title, axes, headings, legend, footnotes and source to find out the context and expected reliability of the data.
Step 2: WHAT do the numbers mean?
Make sure you know what all the numbers (percentages, '000s etc) represent. Look for the largest and smallest values in one or more categories or years to get an idea of the range of the data.
Step 3: HOW do they change or differ?
Look at the differences in the values of the data in a single data set, a row, column or part of a graph. Repeat this for other data sets. This may involve changes over time, or comparisons within categories, such as male and female, at any given time.
Step 4: WHERE are the differences?
What are the relationships in the table that connect crime, ages and gender? Use your ideas from Step 3 to help you make comparisons between columns or rows in a table or parts of a graph to look for similarities and differences.
Step 5: WHY do they change?
Look for reasons for the relationships in the data you have found by considering societal, environmental and economic factors. Think about sudden or unexpected changes in terms of state, national and international policies or major events.

Table 3. Slides using the Five Step Framework for reading tables and graphs in Module 7 & 8.



Modules 9 to 17 were designed to encourage students to think critically about the material seen in newspapers as well as the academic material encountered in their studies. These modules introduce students to probability, sampling and variation, as a rudimentary understanding of these concepts is essential for critical reading. Table 4 gives examples from modules 9 and 15.

Table 4. Slides from Modules 9 and 15



The project

The project undertaken over 2010 to 2011 had three main aims:

1. To develop *Numeracy Modules* to enhance first year undergraduate students' numeracy, where numeracy is about developing and applying mathematical concepts
2. To evaluate the effectiveness of the *Numeracy Modules* to enhance students' learning
3. To investigate students' preferred characteristics of *PowerPoint* presentations

To achieve these aims it was necessary to undertake a number of tasks. These overlapped during the time of the project. For each module the authors jointly determined the sequence for the content, with some consultation with other staff members. This led to the building of a matrix detailing the parts of the modules that would be used to develop declarative knowledge (developing factual recall) and the elements that would assist in the creation of non-declarative knowledge (development of practical skills through the application of knowledge). The scope and sequence can be seen in Table 1.

Evaluating learning

The development of the presentations is a complex process hence the first eight were developed for use in semester one 2010 and the others developed later for semester two 2010 after reflection on feedback from the first eight. To measure the effectiveness of the learning the authors identified the kinds of questions to be developed for diagnostic and post-module multiple-choice quizzes. The construction of the diagnostic and post-module quizzes involved strict adherence to the content of the modules, so that a measurement of learning outcomes could take place. Each quiz has seven questions and each question in the diagnostic 'matches' the corresponding question in the post-module quiz. To help

avoid the possibility that the difficulty of the questions could skew the results, pairs of questions were created and then randomly allocated to either the diagnostic or post-quiz. By creating this balanced assessments structure, the change in performance could then be used as a measure of the effectiveness of the learning program. The software used informed the students whether their answer for each question was correct and if incorrect the reason why they should have chosen the correct answer and not the one they chose.
An analysis of the results on the quizzes was done prior to Semester one 2011 to ascertain the appropriateness of the questions. For instance, questions that were too difficult (i.e. a high percentage of students got them wrong on both quizzes), were simplified and questions that were too easy were modified, to develop a reasonable assessment of what students had learned.

Evaluating presentation preferences

Hilliard constructed the Control Version set of *Numeracy Modules* using an optimised content structuring system, which is based on cognitive templates (Hilliard, 2010). The creation of the Control Versions used the application of a combination of seven key-variables to the design. These variables were colour, background type, slide layout, visual content, text type, graphic utilisation, and animation. This 'optimised' approach was developed through the collation of a wide range of results from research in the fields of education, psychophysics and biopsychology. In each case the variants for each module modified just one aspect of the visual representation of the presentation, so specific variations from the controls could be used to determine how visual differences impact student comprehension and impressions. In addition two other kinds of quizzes were prepared. The first requested demographic information to be completed at the beginning of the modules and the second, an impressions quiz, to be completed at the end of each of the modules. The impressions quiz (the same for each module) was designed to evaluate the students' reactions and preferences in connection with the actual presentations, not the content.

Access to the Numeracy Modules

During the project in semester one of 2011 the students were given a set of instructions (see Table 5) about the sequence to be followed to complete the modules. Students could not proceed through the modules until they had first completed the diagnostic quizzes. If completely correct, students could proceed to the next module; if not they had to go through the *PowerPoint* presentation and then attempt the post-module quiz.

Table 5. Steps for completing the Numeracy Modules

Step 1: Open the diagnostic quiz for the Module One. There are seven questions in each quiz, and you need to select the correct answer from one of four options. Read each question and answer carefully, because you only get one chance to respond to each question and you can't go back to change an earlier answer. It's worth taking your time to make sure that you get all of the questions in the diagnostic quiz correct, because this allows you to move on quickly to the following module.
Step 2 Option 1: After you have finished the quiz, the LMS will tell you whether you answered all of the questions correctly. If you have, you can move straight on to do the diagnostic quiz in the next module (i.e. go directly to Step 5), because the next module will be exposed to you. This is a great time saver, because you won't need to revise information that you already know.

Step 2 Option 2: If you did not get all of the answers in the diagnostic quiz correct, then download the presentation for that module. After you have downloaded the presentation, start it and view the content in its animated format. This will allow you to refresh your memory on the subject, or learn important information, prior to taking the post-module quiz.

Step 3: If you took Option 2 for Step 2 and worked your way through the presentation, take the post-module quiz as soon as possible after you have finished. These quizzes are very similar to the diagnostic quiz you took in Step 1, and they are designed to check whether you have learnt anything from the presentation.

Step 4: As soon as it is practicable after finishing Step 3, please fill in the information in the post-impressions survey. This information is really important, because it will allow us to shape future modules to best meet everyone's needs.

Step 5: Having completed that module, you can now move on to the next Module in the sequence and work your way from Step 1.

Additionally, during the study period in 2011, follow up emails were sent to students to provide appropriate support and technical assistance. Reminder emails were also being sent to encourage students to continue with the modules. As a result of feedback indicating that the first six modules were a bit too easy for some students it was decided to allow students access to any of the modules one to six, without necessarily completing the quizzes, from semester two 2011. This meant that they could start the sequence from module seven. Students were still requested to complete the demographic and impressions quizzes as before.

Unfortunately during the project in 2010 and 2011 it was not possible, due to assessment allocations in the units at the time, to allocate any marks to the students for completing the modules. Post the project in 2012 this has changed, but the marks allocated constitute only 2.5% of the total grade for the Foundation Unit that they take. These are allocated according to their performance on five required modules, modules 7, 8, 9, 12 and 15.

Project outcomes

Evaluation of the effectiveness of the PowerPoint presentations to enhance students' learning

Improvements were calculated for students who completed both diagnostic and post-module quizzes, that is, for those who did not get all the answers correct in the diagnostic quiz and so worked through the presentation and the post-module quiz. This improvement is defined as the number of post-module quiz questions answered correctly by students who got them wrong in the diagnostic quiz. The data are then expressed as a percentage of the group of students who did not get the matching question correct in both quizzes. For the project time in 2010 and 2011 it was estimated that the improvement in learning for the Control Versions was on average about 59%.

Students' preferred characteristics of PowerPoint presentations

An analysis of the impressions survey shows an average of 3.8 on the Likert scale which uses strongly agree, agree, disagree, strongly disagree, and has a maximum value of 4. Therefore this average response is very positive.

A few examples of students' comments are given here:

- *I have never been a great maths person but after reading through the power point programme you have on here, the colours and large writing kind of helped me remember and stay in my brain.*
- *Attention grabbing, not dull.*
- *It broke the problems down and made things easier to understand. I have a psychological block as soon as I see percentages or decimals but this helped tremendously.*
- *How easy it was to understand in comparison with many other learning resources.*
- *I have completed all 17 of the LMS numeracy modules and found them really helpful. Thanks again.*

Presentation variations in Table 6 were investigated, with two per module being examined. The variations modules were randomly allocated to the Foundation Units, each of which had a diverse range of students.

Table 6. Variations in the presentation characteristics

Sans serif font	Vertical text
Overuse high hue yellow	Negative connoting bullets
Warm colour bias	No text removal
Cool colour bias	Text clearing by removal
Almond background	Avoiding double cueing
Yellow text on dark blue background	Asynchronous vs synchronous animation
Overuse of red	Symmetrical vs non-symmetrical synchronous animation
Non conforming scan	Animation fly over
Non enclosed headings	Vertical fly in
Incongruence	Controls aggregated score
Low complexity	Very high complexity

Currently more research is being done to analyse the preferences for the characteristics, but here are some preliminary findings from Hilliard's research:

Sans serif font. A great deal has been written on preferences for serif and sans serif fonts. Interestingly, both experiments are currently leaning toward a impressions preference for sans serif fonts, but the difference is not significant. On the other hand the comprehension was much lower (only 43.9% improvement) for the sans serif font, than for the serif font.

Yellow text on a dark blue background: Interestingly, the results indicate that many people prefer this colour scheme, but it provides significantly poorer comprehension, at 20.5% across the sample. From working with individual students, it can be seen that the yellow attracts the eye off the blue background for a moment, but then the eye returns to the background quickly (even in circumstances where a great deal of attractive force was applied in the animation sequence). In practical terms this means that the poor comprehension stems from the fact that the eye is not able to properly read the content, because of the colour combination.

Overuse high hue yellow. Lower preferences were given by students for this characteristic than some others. This aligns with the hypothesis, which is linked to over-energising the neural visual pathways, so this was expected. Additionally, this only generated a 42.5% improvement in scores, so comprehension was poorer than the average across all of the controls.

Cool colour bias. This generated significantly higher impressions than the control, which is really interesting as a finding and was unexpected. Additionally, the cool colour bias is generated significantly higher levels of knowledge improvement, with a 57.4% improvement overall.

Implementing the modules

The data collection stage using the quizzes for Hilliard's research is over and more analysis will further inform the researchers about using this mode of presentation. Currently, in 2012, students have the opportunity to gain up to 2.5% of the marks for a Foundation Unit by completing a selected five of the modules. It is hoped to increase this percentage allocation next year. The following instructions are given to students in their learning guide as shown in Table 7.

Table 7. Instructions to students in 2012

Access the online unit, Numeracy Modules, via your *MyUnits* page. The first six modules review the maths you learned at school, while Modules 7-17 support your use of numeracy for critical thinking. Of the seventeen modules, you are required to complete modules 7, 8, 9, 12 and 15 by the end of week 8 as part of your Foundation Unit assessment. These five modules are required for completion, as they are directly related to your development of critical reading at university level; the remaining modules are optional – choose from them to suit your personal needs and interests. When you first access the online unit, you will see only Modules 1 to 7. Some modules after Module 7 will not be available until you have completed earlier required modules, as the following table shows:

After this module is completed …	… these modules will become available
7	8
8	9
9	10, 11, 12
12	13, 14, 15
15	16, 17

For each of the assessable modules 7, 8, 9, 12 and 15:
View the *PowerPoint* presentation that explains the topic.

- After you have viewed the presentation, attempt the quiz, which contains 7 questions.
- You can attempt the quiz up to 3 times, to improve your mark out of 7, which will then be counted towards your overall mark for the modules.
- After you have completed a module by viewing the *PowerPoin*t and completing the quiz, the next required module will become available.

The total score for these modules counts towards 2.5% of your mark for your Foundation Unit.

Optional modules: All of the modules contain a *PowerPoint* presentation and a quiz. The quizzes for all of the optional modules are for your feedback and reassurance that you understand the material; they do not count towards your mark. You have unlimited attempts at the quizzes for these modules.

Results from semester one 2012 the first time that a mark was awarded, show that 1081 (65.4% of students) were given a mark above 0; 479 (29%) did not complete any modules. The average mark was 1.84 out of 2.5 and 83.3% of students who received a mark had a pass mark of ≥1.25. Although naturally the required modules 7, 8, 9, 12, 15 had the highest attempts at them (1082, 972, 946, 910, 877 respectively) it was found that 165 students (10%) had completed all 17 modules.

Some discussion with students is planned to find out why there were different numbers of students who completed each of the required modules. It is also anticipated that focus groups of students in 2012 and 2013 will help to identify issues that students may have with the actual content of the modules.

Conclusion

There has been a range of feedback about the modules, mostly positive and particularly once the students were not expected to all complete modules one to six. However, some of the weaker students have found the earlier ones very useful. The online modules provide the opportunity for students to go at their own pace and to go through them forwards and backwards as they wish. Currently the modules have been adapted according to Hilliard's findings but his current work with individual students analysing videos produced by special optical machines may lead to further adaptations.

Staff in the Student Learning Centre at Murdoch University will continue to evaluate the effectiveness of the modules through student feedback so that the best offerings can be given to students. Part of the ongoing work involves working with staff who are often unaware of the extent of the need for students and citizens to seriously engage with quantitative material from a critical perspective.

This project has shown that a set of online modules constructed in *PowerPoint* associated with a set of quizzes can be provided for students to review mathematical content or learn and understand new concepts. The online modules provide the opportunity fro students to review the content of the modules when they want to and they are especially useful for students studying at a distance or who miss in-class time due to illness or other factors.

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