Technology for nurture in large undergraduate statistics classes

Abstract. We report here on a practitioner study of a first year undergraduate service course that aligns a web-based, student-lecturer communication system with the mathematical curriculum. The report presents and analyses data from students and from the lecturer and outlines the nature of the technical interface. We indicate how communication of the students' affective learning needs had a positive influence on the professional development of the lecturer himself. Furthermore, we claim that success of mathematics/statistics teaching that integrates emotional responses from learners is intimately related to the knowledge, skills, beliefs and values of the lecturer.

Keywords: undergraduate mathematics; affect; technology; lecturer professional development.

1. Introduction

This paper reports on and analyses a case study of curriculum development: how technology can provide a means to nurture students' affective responses and help them learn mathematics in large undergraduate classes. Specifically, the mathematics course from which data has been taken for this report was a module, 'STAT1', designed for incoming undergraduate students who were to major in biological sciences; these students generally did not have high entry qualifications in mathematics and for most of them this will be the only mathematics module they will study at university. Furthermore, central to our analysis is the effect that this technology-enabled communication has had on the lecturer's own professional development. We report lecturer-engagement with the personal communications from students and illustrate how this contributes to the lecturer's application in his teaching of his deeper understanding that learning is emotion-driven. We claim that the effects of technological innovation, such as described, are supported by stable values held by the lecturer yet can change beliefs about what is important in teaching.

The paper is organised as follows: Firstly we discuss methodological issues; then we present some background literature. After that, the course context is described; this includes the value-orientation that motivated the lecturer to initiate the e-based 'pastoral care system', as well as student background and the technological infrastructure. Then data are presented with interpretations: both student e-journal entries and data indicating lecturer professional development. Finally, the discussion returns to values and technology in the context of learning mathematics in higher education.

2. Methodological issues

Initially this research was a piece of practitioner action-research by Michael Bulmer: he wanted to find a way of involving the student as a 'whole person' in learning in his large statistics course. He devised an innovation, the STAT1 reflective journal, requiring technological expertise, and used it in 2002. As a result the 2003 class was modified by including an e-journal as part of the curriculum and assessment, and data from these journals were presented and analysed (see below). This was a standard practitioner's action research cycle. However, there were further issues that arose from Michael putting his innovation into action that were open for research, interpretation and theorisation, specifically: the students' affective responses and, the lecturer's values and beliefs. Due to common interests in emotion in learning mathematics at university, a collaboration between Michael Bulmer, the mathematics/statistics lecturer and Melissa Rodd, a researcher in mathematics education was established in order to investigate the following open questions:

- What are the effects of affect when learning (service) mathematics as an undergraduate?
- How can aspects of affect experienced by a lecturer prompt professional development?

The data we had were students' journal entries collected electronically (with pseudonyms allocated), student biographical and assessment data and Michael's response to these. We started by coding and analysing the students' diary entries in a fairly standard "fixed"-design way [1] using quantitative measures (reported below). However, such investigation involved consideration of students' expressing their feelings that had an emotional impact on the analysers. Given that 'affect' was a given category of interest, it became important to report on and investigate further the subjectivities that emerged from the practitioner-researcher, Michael. The research demanded a "flexibility" (see [1] page 4) and qualitative interpretations of data, which included 'meta-data' of Michael's interpretation of his students' responses. Indeed, the adaptations Michael was making in his practice were a result of his beliefs and values as well as his technical expertise. Hence we found we had three strands to be reported: the students' views; the practitioner's development; the values and beliefs. These strands are 'braided' by the technology that underpinned the whole enterprise.

3. Background literature on affect, technology and learning (mathematics) in Higher Education

Lecturers seeking professional development can find self-help books that offer pragmatic advice that includes attending to affective issues in students' learning (e.g., [2]). There are also practitioners' reports of teaching that incorporate responding to students' emotion (e.g., [3]). Some publications offer organising theoretical perspectives that are related to affective aspects of learning, [4]. And there are reports of students' voices: undergraduates have "hot emotional" responses to studying mathematics [5]. The importance of foregrounding the student's affective responses is reinforced by recent neuro-physiological research: emotion and feeling play indispensable roles in reasoning, these affective states are "inherently rational" ([6] page 150). Emotions are elicited that trigger the student to plan for study and participation, or possibly, to be frozen by panic; students' feelings significantly affect their approach to learning.

The nature of higher education teaching changes when up-to-date information technology is exploited [7] and with further technological innovation, there will be further change. These requirements for changes in teaching methods at university have stimulated a research agenda on the practice and nature of teaching in higher education, [8]. Bennett et al. noted "There is a lack of research into effective ways of managing the learning of individuals within large groups" ([8], p30). Our report in this paper is an example of what they refer to as "insider research", ([8], p3), that explicitly incorporates web-based technologies to address emotional aspects of learning mathematics in large classes at university.

The STAT1 course under discussion here is an example of on-line and face-to-face teaching being integrated. Although Coaldrake and Stedman [9] assert that employing ICT will shift the academic teacher's persona from lecturer to facilitator, our case study refutes this generality, as the ICT used is personalised and customised. Another example in which a practitioner uses technology to engage his students' emotions in mathematics learning by personalising the teaching materials is given by Chris Sangwin [10]. In classes of about 200 students, the students have some computer quizzes as part of their assessment and answers are processed by a 'computer algebra system' (CAS) enabling open-ended questions, such as 'give an example of a function with a turning point at x=1' to be used. Sangwin explains how he, the lecturer, can quickly group the students' computer-submitted responses to such a question and use sample responses in the large lecture class. So, in the example mentioned, he can use specific examples students came up with, for example, $y = |x - 1|$, $y = (x - 1)^2$, or $y = \cos(x - 1))$ and draw attention to the different interpretations different students had. This personalisation of examples works with the students on a more emotional felt level and, we conjecture, has profound consequences for their propensity to engage with the abstract material of mathematics.

In an on-going project, Entwistle [11] has characterised ways undergraduate students approach their studies. He notes four principal approaches: deep approach, surface approach, monitoring study and effort

management ([11], p 2). The STAT1 student responses suggest that the course structure did give them increased opportunities for managing their effort, monitoring their study and passing assessments (which could count as 'surface'). Other research on undergraduates studying mathematics found that students at risk of failing were disproportionately 'outliers', unknown to faculty and with low participation in their undergraduate community [12]. The STAT1 course addressed this issue by (a) encouraging students to communicate their feelings to the lecturer through the electronic journals which they completed via the course's web-site, (b) incorporating paired coursework, and (c) setting up 'peer assisted study sessions' lead by successful students from the previous semester's course.

The design for mathematics learning in large undergraduate classes that we are offering in this paper uses web-based technology not only for teaching the content of a mathematics course but also attends to meta-cognitive development through pastoral communication of feeling. When operating within a value-system that respects student feelings, not only because they are persons, but also because the teaching job is likely to be more effective if feelings are developed too, course-design needs to address students' feelings, motivation and development [13] and is a contribution to what McShane refers to as an "under-researched domain" [14] concerning subjectivities of lecturers who teach with ICT.

4. Context: beginning university, learning statistics

Web-based technology was used in the module on statistics for biological science majors, 'STAT1', so that students' affective reactions and feeling states could be acknowledged and respected as integral to their learning. Furthermore, these meta-cognitive awarenesses could be actively developed within the course of studying the module: students were encouraged to learn more about how their feeling states affect their learning within their STAT1 module.

4.1 Values, feeling and course design

Almost all human activities involve evaluation – that is, appraising the activity in question against relevant values, which may be implicit or explicit. In university teaching, there are many explicit standards laid down by senates and by states, which rest on cultural values. For example, in the UK and in Australia, at least in the context of access to higher education, a meritocractic value – 'the best' should have right of access to higher education, has been superseded by values that society is better served by developing a more inclusive access to higher education that will attract a more diverse student body. It is against this contemporary value of accessibility in higher education that the STAT1 course was designed.

In particular, decisions have to be taken by the designer of the course that promote the underpinning values. For example, being told something like "I'm not really a maths person" from several students, the lecturer was aware that there would be apprehension about taking a maths course, so he set out to design a course which had explicit inclusive aims. These included creating a fun learning atmosphere, encouraging interactive learning, going over main concepts, giving examples, and addressing particular problems and concerns of students.

4.2 Technical details

A website was used to manage much of the course. This site provided news, lecture notes, data sets for statistical analysis, and other learning materials, all of which were accessed by students in their own time. The site was also used in formal contact time for running computer laboratories and the end of semester computer-moderated examination. Visiting the site was thus a regular part of most students' lives: during the busiest month of the 2002 semester, students each had an average of 172 visits to pages on the site. A journal page

was created and linked from the site's home page. Unlike most of the pages, students needed to login before accessing this page. The page began with a preamble about the possible benefits of contributing to their journal, specifically the opportunity for reflective learning and for providing continuous feedback to the coordinator. Students were furthermore informed that if they completed entries of at least 50 words in at least 8 different weeks of semester then they would receive a bonus 3% on top of their regular mark for the course. This bonus was to encourage regular entries and was rooted in Michael's belief that regular reflection would be useful in student learning.

The system was based on a simple forms interface and so would work with a range of web browsers. Entries were stored on the web server as text files associated with each student. A limitation of this was that the students who wanted to write mathematics in their entries were severely constrained. Only a small number of students attempted to do this. The lecturer visited a different web page that presented all entries by date and with coded identifiers (allowing tracking of individuals whilst preserving student anonymity). One disadvantage of this anonymity is that the lecturer could not respond personally to some entries, despite many of them asking for a response. Instead common concerns were address in lectures or open responses were placed on a "frequently asked questions" web page.

5. Data

Interpretations of two types of data are presented here: themes from the students' e-journals (there were 770 entries from 96 students, a total of 94,000 words), and reflections from the lecturer indicating professional development issues arising from the students' communications.

Note that the 94,000 words made it impractical for the lecturer to read all entries during the semester. Typically a sample of entries were read when time permitted, with more entries read around significant periods in the course, as discussed below.

5.1 Student e-journal data

Of 136 students who completed the course, 96 completed at least one journal entry and of these, 51 completed at least eight regular entries of more than 50 words in length. This was the stated criterion for receiving the bonus 3%. However, as it was felt that many students who had not reached the target of eight entries had still made substantial use of their e-journal, bonus marks were ultimately awarded to all students who had made at least four entries.

Entries	0-3	4-7	8-11	12-15	16+
Total count	19	17	44	14	2
Count ≥50	27	18	42	9	0

Table 1. Frequencies of numbers of entries by students

The principal grounded themes in the student data were to do with course assessment and with personalising their relationship with the teacher.

Principal theme 1: Assessment

The assessment structure of this course was novel: there was no final exam but three class tests and a practical exam. The strongest themes in the journal entries were those that express strong feeling after one of the class tests, Test 2. This test was held in an 8am lecture and the first entry came 10 minutes after the end of the test; there were entries from 26 students in the first day, totalling 4,000 words. By a week later there had been a total of 78 entries discussing Test 2, with 11,000 words about the test itself. This was around 10% of the total

entries, and 12% of the total words written. A related theme was dissatisfaction with the way tests were marked, the practice of giving a multiple choice test and subtracting marks for an incorrect answer, but giving zero for a blank answer, causing much indignation. Some of these entries are very 'me-centred' oftentimes with huge feeling coming through untamed prose, for example,

> I can't believe how hard today's test was! …Unless u're a bloody statistics genius you haven't got a hope of doing well …I was really hoping to gain understanding and deep learning and I simply cannot with the workload you set.

But others have a more general view of fairness and justice in assessment, for example:

> And while I'll cop it sweet knowing that I still did better than average, I think it defeats the purpose of having a test if a student isn't given enough time to demonstrate what they know.

Principal theme 2: Talking with teacher

There were many entries which communicated with the lecturer – the assumed reader – a problem with a particular concept that the student was asking to be re-explained in a subsequent lecture, for example, the notations 'X' and 'x' caused problems for several. Others requested personal appraisal on 'how can I improve'. Other entries in this theme included gripes like: 'I was sick', 'not enough petrol to get to lecture', 'too many other assignments', 'not enough detail on feedback from project'.

Alternate theme: Subject matter

There were a few 'objectively interesting' entries concerning the subject matter, its relevance or pedagogy. For example a student of music theory wrote how he was fascinated by the 'fractal music example' and goes on to raise serious questions about analysis of musicality of sounds using statistics; an environmental science student relates how her new statistical knowledge has helped her interpret data.

5.2 Data indicating professional development

Professional development of university lecturers can be thought of as either externally organised, or self-directed. An example of the former would be when a lecturer is expected to take a course to develop particular skills, for example in new technology. But this report is concerned with professional development of the self-directed, 'inside' type [15]. This is characterised by a lecturer changing his/her views, as a result of some experiences, then, following up this change of view-point with actions in the professional domain. In our case, Michael reports that:

> Usually the lecturer is there to change the students' lives, but here the students changed my life, in the sense that I became significantly more aware of their internal lives and the effect this seemed to have on their learning mathematics. More specifically, awareness of student anxiety, coupled with the belief 'an anxious student learns less', stimulated a change of approach during the course.

Furthermore, the journal was a source of "energy" in his thinking, which reminded him about all the different views of the students. Rather than being a direct conduit for change, it was the main source of the expressions of student feeling, which lead to professional development in terms of both attitude (as expressed above) and action in terms of course design: relevant subject matter, several short assessments and practical assessment.
In additional to this broad view, it was also the particular critical incident that was important. Michael reports a 'disturbance', in the sense used by Mason ([15], p139):

> Given the large number of entries each day, it was the occasional entry that described a strong emotional response that most caught my attention and led to deeper changes in my feelings about the course and the students. For example:
>
> "I came out of that last test feeling ill. Knowing I could do the questions, but again, not giving myself enough time to get through them. I even screwed up the easy ones. What is wrong with my head? ... No more excuses. Just disappointment."
>
> This single entry brought the awareness to me that the tests were having a physical effect on at least one student and that they could lead to a sense of hopelessness and resignation, all the more significant since the same student had started their journal by writing "I am thoroughly enjoying the course". It was this awareness that led to action.

The increased awareness of students' internal lives is a general aspect of professional development that was stimulated by the specific writings of these students in STAT1.
We now exemplify a further aspect of professional development that was stimulated by journal entries: how to resolve the question of which students should work together for group work. Firstly, here are a couple of journal entries, from different students (both female), which prompted re-thinking of course organization:

> it was pretty stupid going with diana for the assignment, but she is a friend and i couldn't say no to her. she knows even less than i do about stats and has absolutely no idea what a 'p' value is let alone how to interpret it.
>
> I have finish the last the project last week, I feel release. I have done two projects with my friend. I did not feel very good about that. It's not that my parner and i did not know each other. Also we are good friends. The problem is that we are good friend. It's too hard work together. We have different oppions and own knowlege. Sometimes, depend each others. It's just too hard to work together, and there is not good for friendship. Anyway, we finish the projects. thanks god.

And Michael writes to Melissa:

> These two excerpts are particular relevant to me right now. The role of friendships in learning seems an interesting area. I would have thought previously that friends would more easily provide constructive criticism but perhaps there is also the desire to not hurt each others "feelings".

So these very particular e-journal responses have stimulated looking at improving the group work in the course, one feature of which is whether to use self-selected groups or assigned groups.

6. Discussion: Technology, professional development and student learning

From the underpinning values of inclusivity and wish to nurture learners, the lecturer, Michael, held beliefs that directed the assessment structure of the course. He believed that greater continuous assessment would be popular with students, removing the pressure of a final exam, and the reflective online journal would provide greater opportunities for students to demonstrate their learning. However, the journal provided evidence of student anxiety and stress as a result of the new assessment structure. The lecturer's awareness of this student discomfort, coupled with another belief - that an anxious student will tend to adopt a more shallow approach to their learning - led to changes in his practice of teaching: the assessment was changed again to make the in-semester commitments less stressful for students, and further support was provided in the form of learning

materials, including the writing of a "friendly" textbook, and a greater emphasis on the peer-assisted learning environment [16, 17].

The technology enabled some effects of student affect to be communicated to the lecturer. While the technology, itself, could be employed in any discipline by faculty seeking a rich feedback about their students' view of their course and their teaching, it is the case that in mathematics, undergraduate students typically work on problem sets of questions that traditionally do not offer an opportunity for expression of feeling in the submitted version. Hence, arguably, it is particularly relevant in the discipline of mathematics, where that emotional layer is hidden in its public expression, to be able to build communication systems, such as described, seamlessly into the course design. The possibility of doing this effectively in a large class depended on a technological interface that could be used fluently by staff and students.

This report shows how the technological interface specifically stimulated an aspect of professional development in the lecturer that developed his awareness of the importance of students' feelings in learning. The intensity of the felt personal communication, expressed by Michael as "a huge proportion seem to be talking to me as the reader", served as a continual prompt to do a good job for the students, who were making their feelings known to him throughout the course. But of course the prompt only has effect when a value system is in place that supports the lecturer's actions. So our 'braided' image emphasises the holistic nature of our claim: that it is the practitioner's values together with his/her imagination with and proficiency in available technology that facilitates changes in beliefs and hence new practices in lecturing in Higher Education; this paper specifically addresses issues of self-observed changes in beliefs.

References

[1] Robson, C., 2002, second ed., *Real World Research: a resource book for social scientists and practitioner researchers* (Oxford: Blackwell).

[2] Gibbs, G. and Jenkins, A.,1992, *Teaching Large Classes in Higher Education* (London: Kogan Page).

[3] Gregory, P., 2004, *MSOR Connections*, **4** (3), 26-28.

[4] Hatvia, N., 2000, *Teaching for Effective Learning in Higher Education* (Dordrecht NL: Kluwer).

[5] Rodd, M. M., 2002, Hot and abstract: emotion and learning undergraduate mathematics, *Proceedings of the second International Conference on the Teaching of Mathematics (at the undergraduate level) John Wiley and University of Crete: Crete* (http://www.math.uoc.gr/~ictm2/Proceedings/pap203.pdf).

[6] Damasio, A., 2003, *Looking for Spinoza: Joy, Sorrow and the Feeling Brain* (Orlando, Florida: Harcourt inc).

[7] Laurillard, D., 2002, second ed., *Rethinking University Teaching* (London: Routledge Falmer).

[8] Bennett, C., Foreman-Peck, L. and Higgins, C.,1996, *Researching into Teaching Methods in Colleges and Universities* (London: Kogan Page).

[9] Coaldrake, P. and Stedman, L., 1999, *Academic Work in the 21st Century* Higher Education Division, (Canberra: Department of education, Training and Youth Affairs)

[10] Sangwin, C. J., 2003, New opportunities for encouraging higher level mathematical learning by creative use of emerging computer aided assessment, *International Journal for Mathematical Education in Science and Technology* **34**(6), 813-829

[11] Entwistle, N., 2003, Concepts and conceptual frameworks underpinning the ELT project. *Enhancing Teaching-Learning Environments in Undergraduate Courses Project* (Edinburgh: School of Education University of Edinburgh).

[12] Macrae, S., Brown, M., Bartholomew, H. & Rodd, M. (2003) An examination of one group of failing single honours students in one university. *MSOR Connections*, **3(**3), 17-21.

[13] Dweck, C. S., 2003, Ability conceptions, motivation and development. *British Journal of Educational Psychology, Monograph Series II: Psychological Aspects of Education – Current Trends*, 13-27.

[14] McShane, K., 2004, Integrating face-to-face and online teaching: academics' role concept and teaching choices. *Teaching in Higher Education*. **9** (1), 3-16.
[15] Mason, J., 2002, *Researching Your Own Practice: the Discipline of Noticing* (London: Routledge Falmer).
[16] Topping, K.J., 1996, The effectiveness of peer tutoring in further and higher education: a typology and review of the literature, *Higher Education* **32**, 321-345.
[17] Bulmer, M. & Miller, V. (2003) Pastoral care for large classes. *Proceedings of the Fourth Southern Hemisphere Symposium on Undergraduate Mathematics and Statistics Teaching and Learning* (Queenstown, New Zealand. International Delta Steering Committee) 71-77.