Case studies of **EPISTEMOLOGICAL** access in Foundation/Extended Curriculum Programme studies in South Africa

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CASE STUDIES OF EPISTEMOLOGICAL ACCESS IN FOUNDATION / EXTENDED CURRICULUM PROGRAMME STUDIES IN SOUTH AFRICA

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INTRODUCTION

In 2011 Sioux McKenna gave a series of workshops to ECP staff at UWC on enabling ‘epistemological access’. Two years previously she had given similar workshops to staff at CPUT. Staff at UWC were keen to have some sort of follow up to the workshops. In addition Sioux and the staff at UWC and CPUT, while acknowledging that learning about epistemological access (EA) had occurred, were keen to examine how this concept could be put into practice. What sorts of curriculum innovations could be put in place to enable epistemological access? How well did these work in enabling epistemological access from the perspective of students?

In order to pursue these questions the two universities set up a two and a half day writing retreat, chaired by Sioux McKenna, Viv Bozalek and James Garraway, in which staff were given an opportunity to design (or even review) innovative examples of teaching towards epistemological access. These were then collected into short case studies, which were finally compiled into this booklet. The purpose of the collection was to serve as a teaching resource for year one / ECP lecturers. The book itself is something of a work in progress, or conference proceedings, rather than a finished product but we hope that other staff will find the ideas expressed useful for their own teaching, even if the papers are at the moment incomplete. Though there has been editing work done it was more focussed on overall
academic coherence. Many of the cases are currently being developed by the authors further into publishable articles.

It is well known that students coming into our universities are beset by a number of challenges. These challenges include lack of funds to pay fees, difficulties in finding suitable accommodation and even difficulties in accessing learning resources. In addition there are the social and psychological problems of entering an often foreign social and cultural environment, far away from home and friends. Universities have bursary schemes such as NSFAS, accommodation committees and student counselling services whose role is to help students overcome these obstacles. Some of these problems relate to the sense of being or becoming a student and most likely play some role in students’ ability to gain access to the epistemologies of their chosen programmes. However, in this collection the focus is mostly on the provision of classroom activities that enhance students’ chances of gaining EA. The question then is what sorts of learning opportunities are most appropriate to help students gain access to the knowledge in the courses they are studying.

Nomative theories of student learning suggest that the lecturer needs to expose students to knowledge in the field and students will, on their own, be able to piece together how it works. In this autonomous model, students intuitively discover and understand the mechanics of the taught field, and are thus able, given that they apply themselves diligently enough, to both understand and even, at higher levels, produce knowledge in the field. When students find this difficult or even impossible to do then the fault must lie with the student; students may be cognitively unable or just too underprepared to grasp the concepts in the field. Alternatively, or in addition, the student does not spend enough time, or at least the right sort of quality of time, paying attention in lecturers and studying at home. Currently and in the past the solution to this problem, based on this autonomous understanding, has been the provision of bridging courses, more lectures, more tutorials and more time to study. When students struggle and fail their courses, which they often do despite these interventions, the fault must have been mainly because of their own deficits.
Questions began to be raised both about the suitability of these sorts of interventions as well as what the causative features of student failure might be. Bridging (often involving repeating Matric) and more time spent on teaching approaches to support student learning at university were characteristic of the old foundation / bridging courses in the 1980s. The outcomes of these courses fell far short of the hoped-for large increase in graduation numbers. In addition attention was paid to who it was who was failing at university. Studies in America and in the UK (for example the work of James Gee and Brian Street) suggested that academic success was somehow related to earlier enculturation and that this was in turn related to social class and race. These studies suggested that the university privileged some cultural ways of being and knowing over others. Studies in Britain (for example Becher and Trowler's Academic Tribes and Territories) further suggested that even within the different university fields there were particular and different cultures which determined what could be done and said in the field. Something appeared to be amiss with a reliance on the autonomous model of explanation for university failure.

This is precisely what Wally Morrow, then a Professor of Education at the University of the Western Cape, had observed in his students. At the time of great political turmoil in the 1980s UWC had a flexible admissions policy. For Morrow the concept of access, while being maintained as politically and socially just in the then South African political climate, needed to be retooled. Morrow argued that more open physical access to university courses needed to be followed by epistemological access.

The theoretical turn for Morrow was that the really important access needed for success at university, epistemological access, involved ‘learning how to become a successful participant in an academic practice’ (Morrow, 2000: 77). Morrow was not somebody who believed that epistemological access could be transmitted or given to somebody. It always involved hard work and active engagement on behalf of the student, but he also indicated that the notion of enabling epistemological access had major pedagogical and curricula implications. Morrow, however, did not fully articulate what was meant by EA, nor what an EA-focused pedagogy might involve.
Subsequent developments by Boughey, McKenna and Clarence (see for example Beyond the University Gates) expanded the concept of EA to include the interpretation of knowledge within the academic field as well as the production of knowledge. Both modes involve an understanding and development of the rules which govern how knowledge is typically organised in a field, what can and cannot be presented as evidence and, for example, how argument is typically chosen and presented.

Though there is widespread agreement amongst practitioners that this is the sort of approach we should be taking there is less overt knowledge about how EA could be enacted in the classroom. This was the focus of the workshops and of this book.

The case studies cover a wide variety of interventions, including the use of modelling and role play, peer marking, service learning and language interaction. In all the cases the attempt has been to induct students into the ways of doing and thinking in the field.

The paper by Short and Jürgens examines how connections and relations between concepts can be made more apparent in Biology through the use of concept mapping techniques. Slattery uses modelling techniques to help students grasp the underlying structure of biological molecules in a Dentistry course and Gill operationalises modelling techniques to promote epistemological access in Anatomy and Physiology classes in Nursing. Arendse and Jürgens consider the use of ‘clickers’ to get quick feedback on student learning in an Accounting class. Herbert et al suggest a variety of classroom techniques to promote students’ ability to link concepts and knowledge structures in Physics.

Service learning, as a form of project-based learning, can also provide a means through which students are encouraged to grasp the underlying concepts of their discipline; St Clair Henning details how students learn through having to teach members of the community in the field of Food Technology. In a similar vein, Garraway describes how peer learning / teaching may help students understand the underlying rules for solving Engineering problems.
Carelse describes how a constructivist approach can be used to act as a bridge between students’ local understandings and the more ‘scientific’ discourse of Social Work. Rohlwink gives a detailed account of teaching and assessing in order to provide students with access to quantitative reasoning discourses necessary to understand the Design field.

While these case studies are still in-progress, they provide useful and thoughtful ways of teaching towards the epistemology of the target discipline.

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MULTIPLE MODES OF EPISTEMOLOGICAL ACCESS IN PHYSICS


1 INTRODUCTION

The Physics Department at the University of the Western Cape embraces innovation in the context of course design and teaching approaches and has actively encouraged research into Physics education. The Science Faculty Extended Curriculum Programme (ECP) centres on the introductory Physics and Mathematics offerings, which are full credit courses extended over two years (Lesia et al, 2008). The ECP Physics model can best be described as a ‘slow-intensive’ programme with additional innovative content, the purpose of which is not only to address student under-preparedness but also, and more importantly in our view, learning for professional development (Boughey, 2005 and 2010). McKenna (2004) points out that the single most significant factor affecting student success at university is the gap between the ways of knowing students come with from school and those which the curriculum exposes them to. Traditional Physics courses tend to cover a series of topics and practices in logical order with very little or no time available for dealing explicitly with the ways of knowing in the discipline. Since Physics is a discourse which is strongly hierarchical (Lindstrom, 2010) it is understandable that Physics educators deliver courses in a way that builds in complexity and deemed level of difficulty, an approach that assumes certain topics to be ‘basic’ and others ‘advanced’. Educators of Physics seldom succeed in students’ gaining the required deeper level of understanding that underlies key concepts and procedures. Little attention is given to making explicit the links between concepts and the structure of knowledge in the discipline. Together with this, students adopt negative attitudes towards Physics and view the subject as
mathematical in the context of substitutions and solving equations, not appreciating the wider aspects of the discipline and its relevance to their everyday lives. The ECP Physics course is therefore designed around the central view that an introductory course should make the practices of physicists explicit and provide what Morrow (1993) terms ‘epistemological access’ to the discourse. This case study argues for the need for a multimodal approach to delivering an epistemologically-centred course.

2 HELPING STUDENTS ACCESS THE DISCOURSE OF PHYSICS - WIDENING EPISTEMOLOGICAL ACCESS

The curriculum design of this introductory Physics course has been influenced by more recent sociocultural perspectives on science learning (Leach and Scott, 2003; Sfard, 1998). Such perspectives suggest that an exclusively individual or cognitivist perspective on learning may need to be complemented by perspectives on learning which recognise the social contexts in which science learning takes place, and which place a greater emphasis on learning as participation and identity development. In this sense, learning is viewed not just as a cognitive process, but also as a process of identity formation through accessing a disciplinary discourse and increased participation in the activities of a community (Brown et al, 1989; Lave and Wenger, 1991). ‘Discourse’ refers to the way in which a discipline represents itself – not just in words, but in graphs, symbols and how its artefacts are used, as well as the value commitments that underlie these representations; the ways of thinking, acting and valuing of that discipline (Gee, 2000; Airey and Linder, 2009).

Learning Physics should not only be about content but also about social practices as well, because students are required to take on particular vocabularies and ways of reading, talking, writing, listening, solving problems and discussing, and also ways of thinking and behaving like physicists. For instance, the multiple representations approach of van Heuvelen (1991) is regarded as not just a problem-solving skills approach, but also as a way of assisting students to take on particular ways of acting that characterise the
social practices of Physics. Moreover, if students are thinking about formulae in terms of recipes for solving problems rather than of getting to the fundamental principles of understanding how to solve a problem, they are unlikely to be able to think about Physics in terms of a coherent structure of concept-based problem-solving approaches, as practicing physicists do (Wieman and Perkins, 2005). However, when students are modelling an object as a particle to represent a physical interaction and are able to describe this verbally and represent it symbolically and to evaluate their solutions, then, as Hewitt (1983) points out, this is a critical aspect of coming to understand Physics. This approach takes on the ways that the Physics community engages with the content, the experience and the actions of the discipline of Physics, as pointed out by Wieman and Perkins (2005), and does not treat them as disconnected pieces of information to be memorised without understanding.

In a broader context, we believe that a good foundational course must prepare students to function as informed citizens in an increasingly technological society and world. A lack of ability to evaluate information in a scientific manner might limit their level of participation in solving the problems of the future and hence put their place in society at risk. Key to this approach is that students are taught the social and academic contexts in which a scientist works. Students are guided to appreciate the importance of the knowledge they already possess and will learn and create as practicing scientists. They are made sensitive to the moral and ethical issues involved with making decisions regarding the application of this knowledge (McKenna, 2010).

3 THE LEARNING MODES
3.1 The curriculum

The current curriculum structure reflects the course focus on the nature of science and practice of a physicist. Whereas a traditional first-year Physics course starts with Mechanics and ends with modern Physics, this course starts with modern Physics taught conceptually – the Hewitt approach (Hewitt, 1998). The motivation for this approach is to break students’ view of Physics
as an extension of Mathematics in which equation substitution and routines are the principal activities to master, and to replace this with a broader, more holistic view of Physics as a larger body of knowledge that has relevance to their everyday lives. Rather, the mathematical aspects are introduced as tools in forming, presenting and communicating Physics concepts and principles in a concise way and in modelling natural phenomena. Another reason for introducing seemingly advanced topics like atomic structure and nuclear physics early is to forefront the construction and development of scientific knowledge such as the development of the models of the atom and its impact on society, e.g. modern technology, nuclear power. The students are provided with the opportunity to ‘take part’ in this process through guided readings and exercises and simulated laboratory investigations which re-enact important historical events in terms of scientific discoveries, e.g. Galileo and the falling balls from the tower of Pisa, the discovery of the nucleus.

In helping students to begin to ‘think like a physicist’, we have found that van Heuvelen’s multiple representations approach to teaching Physics (van Heuvelen, 1991) is a powerful way to make explicit for students the different verbal, pictorial, physical, graphical and mathematical representations that comprise the disciplinary discourse of Physics. Viewing learning as acquiring the discourse of Physics implies that students need to be explicitly guided to develop the ability to shift between these multiple representations, a facility which Airey and Linder (2009) term ‘discursive fluency’. This focus on multiple representations is the approach adopted in curriculum materials used in the course (Etkina and van Heuvelen, 2007; Knight, 2007). Students are required to understand concepts and communicate their understanding of these concepts in words, diagrams, graphs and then finally mathematically.

How Physics knowledge is constructed and structured is also addressed explicitly. The nature of science underlies all content delivery and the scientific method is actively and directly taught as the framework for generating new knowledge in science. Since the more mathematical aspects are only introduced later in the course, the notion that concepts are more important than details is emphasised. Class activities are centred on investigation and/or solving problems. Experimental exercises are designed
around the idea of a scientific investigation that employs some aspects of the scientific method, rather than the more traditional ‘recipe’-type student-laboratory practicals which give students narrowly-defined procedures to follow.

The curriculum is thus designed to emphasise and make explicit the interconnectedness of Physics knowledge across the different areas – to address students’ perceptions that Physics is a set of disconnected topics. The hierarchy of Physics knowledge is presented to the students in a holistic manner as one cannot simply assume that students are able to automatically relate the various levels and fields of knowledge in the discipline.

3.2 The classroom

Physics Education research trends have suggested that teaching Physics using non-traditional instruction methods, specifically those where students are actively involved and engaged, promotes their learning (see for example Wieman and Perkins, 2005; Etkina and van Heuvelen, 2007). The ECP Physics course designers concluded therefore that the traditional lecture and consequently the large lecture theatre would be unsuitable for delivering all the aforementioned aspects to a student cohort as previously described. The classes are interactive where the lecturer’s role is to facilitate students’ learning, i.e. student-student and student-lecturer engagement and interaction – best described as a ‘lectorial’. To deliver the lectorials, a flat-space venue was found and converted to look like a scaled-down, low-technology version of the SCALE-UP\(^1\) classroom, as widely adopted in the

\(^{1}\) Student-Centered Active Learning Environment for Undergraduate Programs – developed at North Carolina State University in the USA. The classroom is designed around the students with the lecturer and assistants as facilitators. The typical SCALE-UP venue has large round tables with three teams of three students per table, with each table having access to a whiteboard nearby. All activities are investigative and activities require
USA (Beichner et al, 1999; Beichner, 2008). The floor space is occupied by 10 large workbenches which are permanently fixed to the floor. The room is used for all class activities, including practical experimental work. Students work in groups of three with three groups seated around each table. The seating arrangement also accommodates focus on short presentations at either end – a screen for a data projector at one end and a multimedia monitor with audiovisual equipment at the other. Full class discussions are facilitated with the aid of a portable microphone. This arrangement allows for maximal one-on-one engagement and interaction as well as encouraging good group dynamics – aligning with co-operative learning principles developed by Johnson and Johnson (1984). Twelve large whiteboards are arranged against the walls between the windows and the back wall to facilitate group interaction and group-lecturer engagement. The venue is situated on the first floor of a university building with many large windows, which allows for good views of the surroundings creating a sense of space and roominess. Light, tight blinds can be lowered over the window openings to create a virtual darkroom for physics demonstrations and other purposes.

The classroom environment is central to the theme of providing epistemological access since peer engagement, group discussion and presentation, collaborative practice and experimentation are critical elements of the practice of a physicist. Even though these are not strictly seen as part of the hierarchy of Physics knowledge, they are acknowledged and deemed desirable in various documents listing the attributes of Physics graduates (e.g. Institute of Physics, 2010).
3.3 Teaching and learning activities

The ‘lectorials’

Student interaction and engagement (group activities, class discussion, peer-marking, self-assessment) enjoy precedence over content delivery. All class activities are structured to encourage students to take responsibility for their own learning – students get the opportunity to engage with the work themselves. In each class activity the learning outcomes are made explicit to the students, and in this way the students are being made aware of how the intended learning fits into the broader epistemological framework. Class activities, learning outcomes and assessment of work are all aligned to promote this goal. In class, immediate formative feedback is given to guide students in their learning. Importantly, the team of lecturers moves about interacting with groups to give immediate feedback and assistance. A lecturer may also at certain key times address the class as a whole to make sure that the key aspects are grasped by everyone before moving on. The lectorials provide the platform for students to learn the ways of doing in Physics in an environment where the process of creating Physics knowledge becomes a real and tangible experience for the students.

The ‘laboratory’

The overarching principles of the Scientific Method, an epistemological view of the learning of measurement and uncertainty, form the basis upon which all laboratory-type exercises and practicals are based and designed. The development of students’ procedural knowledge (Millar et al, 1999) is foregrounded, as is the ‘process approach’ which attempts to organise practical exercises in terms of their specific purposes (Etkina et al, 2007). Thus these exercises and practicals in the ECP physics course are designed to explicitly develop ideas around the scientific approach to enquiry, as argued by Osborne (1996). Students are introduced to and explicitly taught the underlying ideas and methods needed to have a fuller and deeper understanding of measurement, which is a key component of Physics knowledge, rather than just a loose disconnected set of ‘rules-of-thumb’ and
experimental procedures. The communication aspect of the reporting of results of scientific measurement is foregrounded, rather than the focus on experimental recipes to be followed to verify established scientific facts. Throughout the laboratory component of the course, students' report-writing skills are developed by specific and contextualised academic literacy exercises.

Academic literacy infusion

Fundamental to the core philosophy of the course is communication. Our students need to learn the ‘discourse’ of Physics to become good practicing scientists (Airey and Linder, 2009). As McKenna (2004) points out, for students to communicate efficiently in Higher Education institutions, they need to write, talk, listen and read in ways that conform to the dominant discourse of their practice. They are expected to begin to comprehend the strange ‘customs and norms’ which they acquire in understanding the knowledge of their discipline (McKenna, 2010), and therefore the development of academic and scientific literacy, within the broader goal of professional development, is infused into all the aspects of the course. Gee (2003) points out that the goal of learning writing or reading in any discipline is to enable students to write or read specific sorts of texts written in specific ways – that is, the ‘academic language’ or the language of the content areas of that specific discipline. In a broader sense, therefore, the aim is to help students to begin to ‘think like a physicist’.

Reading, writing and computer literacy have thus been explicitly embedded into the lectures, tutorials and practicals (Jacobs, 2005 and 2007). Students are assisted to read and make sense of science texts, interact with the course textbook, construct concept maps, write paragraphs in a structured and logically coherent way, and write coherent summaries and laboratory reports. As Webb et al (2008) argue, science learning is a process which requires the embedding of explicit language activities during instruction. The course assessment schedule explicitly and directly addresses these aspects and provides students with a roadmap for the development of their scientific communication abilities. Computer
literacy is also developed within the context of scientific investigation and the skills learned are directly utilised within theory or practical contexts (Gee, 2007; Mallinson, 2010).

4 MONITORING STUDENT LEARNING

The learning goals of class activities as well as assessment criteria of tasks are made explicit to students. In order to provide students with the necessary guidance in relation to the achieving of the goals, it is necessary to provide immediate feedback to them and to continually monitor their progress. The varying forms of feedback in this course are expanded upon below.

4.1 Formative feedback

As indicated above, students are given immediate feedback on activities in class. Since students are expected to monitor their own learning, it is important for the lecturers to be able to monitor their progress. A variety of methods and aids are used to accomplish this. Flashcards and the electronic classroom response system (clickers) (Beatty and Gerace, 2009; Crouch and Mazur, 2001) are used to assess students’ grasp of key concepts and to gauge their understanding. This is done in an interactive and formative manner. These tools have proved valuable in stimulating student engagement and class discussion (Herbert et al, 2011).

Peer assessment and self-assessment are used specifically when the lecturers want students to learn the importance of communicating key ideas and or skills effectively in written work (Bitzer, 2004). Through these forms of assessment, students engage with each other’s work critically, providing a platform for social engagement around issues of practice and discipline in the discourse. The
lecturers set the assessment criteria, which are aligned with the learning goals and outcomes as explained to students upfront at the start of sections of work. Students seem to find the assessment framework useful and have a positive attitude. The assessment framework is made explicit so that students can learn to appreciate the what, how and why of the various modes of Physics.

4.2 Summative assessment

The university continuous assessment system backgrounds the need to assess students throughout the year. The system requires individual marks per student that reflect performance and progress. The weekly tutorial tests and problem sets are designed as summative assessment tools that allow students on the one hand to consolidate work learnt in class activities and on the other to gain an opportunity to develop collaborative learning and interaction as typical of practice in the Physics community. This is in addition to the recording of marks for class activities. The term theory and laboratory tests as well as the semester and final assessments are all summative.

Group work forms the basis of the weekly tutorial sessions which are designed to consolidate students' learning. Importantly, the tutorial session forms an integral part of the weekly learning activities as set out in the broader learning goal of the course to provide epistemological access. The group work is assessed with all three students in the group being awarded the same mark. Individual assessment in tutorial tests which follow immediately after the group task is designed to give individuals feedback on their own progress. However, students need to develop self-learning and independence and therefore are given a problem set based on the group task which is to be completed by students individually. Students are encouraged to consult the course teaching assistant and the lecturers to discuss any difficulties they may have. Course evaluation questionnaires are completed by students at the end of each term and impromptu discussions with students about their experiences with regard to class and group work also take place. The student surveys consistently indicate that students enjoy the approach and are very positive about Physics as one of their subjects.
4.3 Academic literacy specialist

Unique to this course, perhaps, is the availability of an academic literacy specialist who assists and monitors lecturers and students during class activities. The specialist importantly provides critical feedback on the teaching practice and assesses the success in achieving the learning outcomes. Interactions between students and the specialist occur spontaneously and during class activities. On occasion these interactions may require the specialist either to intervene or to request a clarification from the lecturer, or the information gathered may be reflected to the lecturer, which may in turn then stimulate further discussion. This information is also used in post-class reflection and planning. The role of the specialist is, therefore, not only to provide assistance with unpacking words and phrases which may be strange to students not familiar with the language of the discourse, but also to help the lecturers succeed in giving students access to the ways of knowing in Physics (Jacobs, 2007). This interaction between lecturers and the specialist provides students with firsthand experience of Physics as a collaborative practice.

5 CONCLUSION

Many of the principles adopted in the ECP course have recently been accepted as the basis for re-evaluating all course offerings and for redesigning all of the first-year laboratory courses offered by the Physics Department at UWC. The relative success of the course can also be gauged by the increasing proportion of third year students who started in the ECP course in first year. Second- and third-level lecturers report that students from the Foundation class have a deeper understanding of the work. Though not reported on here, recent student surveys suggest that students are finding Physics more accessible and, significantly, have changed the negative view of the subject which they had when they entered the Extended Curriculum Programme. They now view the subject as relevant to their everyday lives and see the value of studying Physics at a higher level. It is evident that the students' confidence has increased. It seems therefore that ECP Physics is
achieving its goals in giving students greater epistemological access and improving their success in learning Physics.

One of the greatest challenges is to sustain this effort into the future and, importantly from a student perspective, to continue this approach into subsequent years of study. The collective experience of the authors, together with the adoption and implementation of best practices garnered from educational research, have led us to conclude that, in order to give students epistemological access in a strongly hierarchical discourse like Physics, there is a requirement for multiple modes of approach that broaden and link the different levels of knowledge and understanding that students need to succeed.

REFERENCES


INTRODUCING CONCEPT MAPPING AS A TEACHING AND LEARNING TECHNIQUE FOR LIFE SCIENCE ECP STUDENTS

Suzanne Short and Judith Jürgens

ABSTRACT

First year Foundation students in the Life Sciences module at the University of the Western Cape (UWC) generally come to university with many misconceptions about basic biological knowledge. This is often a legacy of poor science education provision at high school level, itself the result of the old Apartheid deficits in education offered to schools of the former Department of Education and Training (DET) (Scott, 2009). For these students, the difficulties are further exacerbated by the large volumes of content expected at university level, content presented in an unfriendly American textbook which is very heavy, expensive and linguistically difficult for most students who are second-language English speakers.

For students to manage the complexity and quantity of biological material covered in their first two years of Life Science at UWC, they need to have a firm basis of accurate conceptual knowledge. In order to assist these students to reconstruct more accurately this knowledge that is assumed to be in place, they were introduced to the technique of using concept mapping. This learning strategy is used in conjunction with, and partly based on, the prescribed textbook – the ‘language heavy’ edition that students did not find easy to use until concept mapping was introduced.
Concept mapping has been used for several purposes: to introduce sections of the content so that students have an overview of the material to be covered in lectures, tutorials and practical laboratory work; to elucidate the connections and relationships between the different sections of work while highlighting the essential material to be learned; and to use as an aid to study, since concept maps lend themselves to summarising sections of the work. This work is ongoing and the research thus far seems to demonstrate the benefit of concept maps for many, if not all, of the students. This paper will give the rationale for the introduction of concept mapping, suggesting how this technique might improve the students’ grasp of essential concepts to encourage deeper learning, illustrate some uses in the classroom and attempt to evaluate the efficacy of the tool for its purported aim.

INTRODUCTION

Currently, South African tertiary funding mechanisms have been intended to encourage the registration of students en masse, ostensibly to increase access for previously marginalised students. One could justifiably conclude, then, that the type of mass approach experienced in South Africa has promoted access for success; however, on the contrary, it has resulted in a high failure rate. Research conducted in South Africa by Bradbury and Miller, (2011), Eiselen and Geyser (2003), Lourens and Smit (2003), Grussendorff et al, (2004), Coughlan (2006) and Scott (2007; 2009) indicates that the typical first-year failure rate in South Africa is roughly 30 percent, with instances of up to 77 percent recorded. UWC recognises that its high first-year failure rates are partly a result of inequalities in the school education system, but also that these inequalities are entrenched by continued unequal financial support for universities. As a result, UWC’s genuine attempt to broaden access to university is undercut (and so continues to prevent epistemological success for its students) because of the current – not only the past – inequity in provision of resources, both human and physical. Nevertheless, the University encourages staff to find ways to redress these inequalities. In one such attempt to remedy the situation, a Teaching and Learning induction workshop was held for lecturers at UWC in March 2010. The workshop was intended to start a process of meeting the need to alter
the approaches and strategies used at the university in order to facilitate real access to epistemological success (Scott, 2009; Morrow, 2009).

It was at this workshop that an article by Hay, Kinchin and Lygo-Baker (2008) on the uses of concept mapping in higher education inspired the idea to introduce this technique as a learning tool. It would be aimed at first-year Foundation students in the Science Faculty at UWC in an attempt to reduce some of the barriers to epistemological success.

Concept mapping is a strategy for arranging knowledge on the basis of an essential ‘map’ of material studied. It is a means of making visual the concepts in a field and of specifying the relationships between those concepts, arranging them so that levels of hierarchy and interconnectivity become manifest (Hay et al, 2008).

At first-year level, there is frequently a lack of clarity on which the key concepts are and also how these relate to each other, and traditional, linear, transmission-mode lectures do not seem able, per se, to ensure the necessary grasp of this knowledge. Many students seem quite capable of listening carefully and copying notes presented to them, and bent heads and copious, neat notebooks attest to this. However, there is no necessary consequent understanding of what has been presented since tests, assignments and class exercises generally demand only the ability for short-term regurgitation of such information. Thus students cannot acquire or demonstrate any aptitude for application or explanation. The aim in this study was to see if concept mapping is effective as an intentional shift away from the pure reproduction of notes to a more constructive engagement with the material on a conceptual level so that it will ‘constitute a knowledge structure that can be studied so that its parameters can be understood’ (Donald, 1983).

**CONCEPT MAPPING AS A TEACHING AND LEARNING STRATEGY TO IMPROVE STUDENT LEARNING**

One reason for introducing concept mapping is to make the Life Science classes more student centred. A more student-centred approach aims to
allow students either to develop further their knowledge of the concepts within a framework consistent with the current area of study or to reconstruct their misconceived ideas of the subject matter. This approach also works from the premise that lecturers would be assisted in identifying and then clarifying any misconceptions for students. The impact of such a student-focused approach on teaching is based on a social constructivist theory of learning which purportedly affects both teacher and learner, enabling teachers to reflect on the strategies they have employed for a critical re-evaluation of their efficacy (Botha, 2009). The teacher’s aim here, then, is that students should gain meaning and engage in deeper learning as they create a concept map for themselves (Biggs, 1999). In contrast, there is no meaning necessarily gained or transmitted simply through direct, logical and clear instruction.

In the first-year Life Science module at UWC, traditional forms of lecturing have relied on the transmission of content to relatively ‘passive’ students, and student success rates have depended upon the accumulation and memorisation of factual content. Although it is important for students to manage the content, this system of learning has previously proven to be an ineffective pedagogical tool in promoting conceptual understanding, given the high failure rates at this level.

As Knight and Wood (2005) point out, ‘Today there is much more information to learn, but the increasingly easy accessibility of facts on the Internet is making long-term memorization of details less and less important’. However, undergraduate Science students are required to ‘know’ core conceptual knowledge and apply these concepts in problem-solving situations. Although the sciences carry greater numbers of discipline-specific concepts, it is the way in which these are structured and related that will provide the parameters for understanding them, and presumably enable a better streamlining and synthesis of the content to facilitate learning (Donald, 1983). What the construction of a concept map requires is this very interrelatedness of the major concepts, as each link between concepts must be identified and labelled.
Jonassen et al (1993) developed the idea of structural relatedness further, referring back directly to Ausubel’s original Assimilation Theory to explore how concept maps make structural knowledge explicit and visual, using the students’ prior knowledge as the basis for constructing new knowledge. This integration or synthesis of the ‘new’ with the ‘old’ knowledge results in meaningful learning. However, where there are discrepancies between known and new knowledge, the concept map makes this disjunction explicit, and implies that, in adjustment, some shift in understanding for the student will take place.

Concept mapping should thus not only be viewed as a strategy for learning, but one that ensures students are actively engaged in the pedagogy. This overtly acknowledges them as constructive agents in their own learning. Such interactive learning moves away from the linear teaching styles mentioned above, whereby the knowledge that is imparted is based on textbook content reproduced in point format. ‘The linear presentation of materials denies the student access to the ways of thinking within a discipline, hiding the lecturer’s expertise and maintaining the separation of teaching and research’ (Kinchin, 2008). The usual rationale for linear teaching styles is that they allow students to obtain the required information that will be examined, a major concern for students in the current assessment paradigm. The drawback of such neatly packaged module content is that not much real learning takes place and thus linear teaching only perpetuates a ‘cycle of non-learning’ (Hay, Kinchin and Lygo-Baker, 2008).

This content-focused transmission of ‘facts’ has long been of concern to educationists (Botha, 2009). Even a hundred years ago, Dewey pointed out that ‘Just because the order is logical, it represents the survey of subject matter made by one who already understands it, not the path of progress followed by a mind that is learning’ (Dewey, 1910: 204). This linear approach is what Trigwell et al (1994) refer to as ‘a teacher-focused strategy’, where the intention of the lecturer is to transmit the content of material without reference to students’ prior knowledge and without their participation in the process of learning. As attempts to get students more engaged in active
learning are made, so the classroom strategies have to change in order for students to begin to construct their own knowledge in the discipline.

In contrast to linear teaching, then, concept mapping engages students' participation and construction of their own understanding of the concepts. This means there is a shift of the teacher's intention from merely presenting content to looking critically at concepts and the relationships between the concepts that are embodied in the concept map. For students, this is a major adjustment from overwhelmingly huge amounts of inaccessible content to a clear and simple visualisation of this knowledge in the form of a map. The construction of such maps demands that students develop their own notes or conceptions, as opposed to them copying the bulleted lists from the PowerPoint lecture slides that are the product of the lecturers' own thought processes. The use of the concept map, then, promotes a reconfiguration of students' earlier conceptions, assisting them to manage the large amounts of information and develop the cognitive skills that university inevitably requires.

Thus an additional advantage to using concept mapping is what Crouch and Mazur (2001) highlight as an activity to involve ‘every student in the class’, peer instruction and joint construction of core concepts. This is not a new idea but exemplifies what Vygotsky (1978) promoted: that focused social interaction supports more effective learning. In this respect, both the lecturer as mediator and the peer as collaborator assist meaningful construction of knowledge.

With this in mind, the development of concept maps should not only be an individual exercise, but also take place in a collaborative manner with team members. In a social constructivist model, this strategy purportedly improves student learning and the learning situation mimics the reality of future work situations.

**CONTEXT OF THE STUDY**

The module under discussion is a core module for Life Science Foundation students whose programmes will later diverge. The module covers basic cell
biology, genetics, ecology and biodiversity. The class sizes are large, with 160 first-time-registered students and approximately 90 students repeating the course. There are three contact hours per week for lectures, a one-hour tutorial and a three-hour practical in the laboratory which consists of wet bench practicals and computer literacy. Based on their Matric results many of the students enrolled for the science course should be sufficiently prepared for tertiary biological education. However, lecturers identify many misconceptions in students’ basic biological conceptual knowledge and so they struggle to disengage from ‘old’ school knowledge and ‘new’ university information on the same topics. It is because of this disjunction between the ‘old’ and the ‘new’ that students have need of extensive support in the Life Science module.

The module design encompasses the same course content covered by the mainstream Life Science students. The foundation students cover the work in two years while the mainstream students cover it one year. Thus the teaching is parallel but the Foundation modules accommodate an extended process of scaffolding. Two lecturers share the teaching load, which is taught in sections with infusion of literacy and computer literacy skills. Senior assistants work with the lecturers to provide administrative and academic support, while the literacy specialist ensures the infusion of literacy skills.

To facilitate these students’ ability to construct essential knowledge (for improved understanding and a broader conception of the field), the lecturers first engaged in developing their own concept maps of the material to be covered in the module. Since all three lecturers were new to the module and were working without the benefit of previous module outlines, lectures or content, this was one way of ensuring that they had a consensus of perception about the major concepts to be studied and the philosophical orientation underlying the development of materials. This required intensive teamwork and consultative planning among all three lecturers who would manage and develop this module for the 245 students enrolled for it, some 65 of them students repeating the module due to failure.
The focus here, then, is on the use of concept mapping as it impacted on student levels of understanding and learning, particularly as a systematic technique of self-constructed scaffolding for learning structural knowledge (Jonassen et al, 1993).

CONCEPT MAPS IN USE

In the first-year classroom, students were taught how to create concept maps in the lectures, first by explaining the importance, principles and benefits of concept maps, and then by illustrating the process using the lecturers’ own models of the whole semester’s content. (It is a two-semester module). After this students were given guidelines on how to draw up their own maps. These were gradually extended and refined after having been introduced to the section of the curriculum in greater detail and referring to the textbook. Selected students had to use their own maps to report back to the class on how they structured and related the concepts in the section. These presentations stimulated discussion, which was facilitated by the lecturer. Students were also asked to reflect on aspects of the course by answering open-ended questions, thus enabling the voice of the student to be heard (Ivani, 1998). Although unfortunately only twelve students responded to the survey, which was voluntary, their comments may be seen as indicative/ representative of likely class responses.

As indicated above, the prescribed textbook proved to be very inaccessible to most students, many of whom are second-language English speakers with a superficial ability to read dense text and extract information, from either the prose explanations or the detailed graphic representations. Since this book was to form the basis for the majority of the content to be taught and tested, it soon became apparent that we needed to ‘teach’ students how to use the textbook, a task that included explicitly showing them how such books are structured – from the imprint page to the index – and how to use the resources provided by the book from information to self-testing exercises to glossaries. Using the textbook as the basis for developing concept maps was thus a way of ‘killing two birds with one stone’: it provided students with some of the scaffolding they needed to create the concept maps, and allowed them to interact with the textbook in a different way, thus possibly
gaining better access to what it offered. Figure 1 (Chapter 7

7

Photosynthesis

kind that shines down on us everyday, contains different colors
violet to green, yellow, orange, and red. Plants use all the
of plants weren't so wasteful and used green light, in addition
appear black to us! Yes, natural areas like the one pictured
brown on the right.

nts do not use green light for photosynthesis! When the
the ocean, green light was already being absorbed by other
selection favored the evolution of a pigment such as chlorophyll.
light. On land, there is plentiful sunlight, and a more efficient
As discussed in this chapter, two interconnected pathways allow
hydrate while releasing oxygen. Such a remarkable process
.

Fig. 1: Chapter 7 Contents

EVALUATION OF THE SUCCESS OF USING CONCEPT MAPS IN THE

In order to establish whether the use of concept maps was effective, we
used a three-part evaluation strategy: we evaluated the concept maps
produced by students to see whether or not their structural knowledge was
coherent and in line with content being taught; we required the creation of concept maps from texts in tutorial exercises, tests and exams; and we administered a questionnaire to a small, voluntary group of students concerning their view of how concept maps aided their learning. Twelve students were willing to complete the questionnaire.

The students’ responses to the use of concept mapping were very varied, but persistence and modelling, coupled with discussion (either in small groups or with the lecturer) of how to choose and place concepts, appears to be showing profit. A student began using the technique for their own study and for getting an overview of content before the material was covered in detail in the lectures. The use of concept maps for own study is not ubiquitous, but several students have requested ongoing class discussion of concept maps during lectures when lecturers can act as guides to the choice of concepts and identifying the relationships between concepts.

The concept maps produced by one of the students on his own indicated the student’s ability to categorise and place the primary and secondary concepts of this section of the content in hierarchical relationships. However, what was apparent was that the student had captured all the major concepts apart from having misplaced the concepts in relation to each other, which affected his naming and understanding of those relationships. This indicated to the lecturer that this student (and possibly others) had not fully understood that energy has been converted from a source to a usable form (ATP). It was clearly difficult to award marks for such an exercise because the variation possible in the arrangement of concepts was considerable. What could be evaluated was whether or not the student was grasping the concepts, so such an exercise provides the lecturer with guidance for follow up. In similar cases, students could be expected to complete new drafts or new concept structures as a result of follow up or feedback.

It was interesting to note that not all the students were comfortable with this new approach to learning the content; many wanted to be given the notes they had to study for tests and exams. Their discomfort was evidence of the power of the linear paradigm. These students were unable to see any
benefits in spending time considering their own input, overtly undervaluing their own contributions and wanting the ‘safety’ of given facts. They found it difficult to adapt to a new teaching and learning style, feeling that it was easier to continue using teaching and learning styles familiar to them from their high schools. The shift that students had to make was from accepting ‘factual’ information in notes from the lecturer to having to construct and make sense of the information for themselves, with the lecturer as facilitator.

From the lecturer’s point of view, the concept maps became a mechanism to determine the students’ level of understanding about the topic before formally introducing it in class, and the maps very quickly foregrounded the students’ misunderstandings and gaps in relation to the content. This then assisted the lecturer to focus on unclear aspects of the module.

Using concept maps for tests and exams requires providing a rubric that allows sufficient specificity to attach marks, but some leeway for structural variation. Ensuring that the content and concepts are easily identifiable is the rationale for using a given text containing concepts and explanations. The students will have to understand the text and the content before being able to produce a comprehensive concept map. An example of just such an exam question and the rubric used can be seen below, in Figure 2 and Table 1.

```
Question 11

Water is essential to all living things. Read the text about water and its properties.

Summarise the text in the form of a concept map, showing the major properties of water in relation to its polarity and hydrogen bonding. Use linking words.
```

[10]
WATER IS ESSENTIAL TO LIFE

Although water may seem to be a rather ordinary fluid, it is not. The tiny, three-atom water molecule has extraordinary properties that make it essential to all organisms. Water is a polar molecule because it has a partially negatively charged oxygen atom and two partially positively charged hydrogen atoms which allows hydrogen bonding with other charged molecules.

A. Water is Cohesive and Adhesive

The tendency of water molecules to stick together is known as ‘cohesion’, without which water would evaporate too quickly. Cohesion also explains why a very full glass of water does not overflow. Cohesion creates surface tension, holding molecules together and providing a surface layer for insects to glide without breaking through. Water molecules are held together by hydrogen bonds and it is these bonds which hold surface molecules together.

A related property is adhesion, the tendency to form hydrogen bonds with itself and other substances. Both cohesion and adhesion are at work when water rises in a diameter tube, soaks up in a paper towel or moves from plant roots to its leaves.
B. Polar Substances Dissolve in Water

A solution consists of a solute dissolved in a solvent. Water can dissolve a wide variety of chemicals, because it is a polar molecule (charged). Water molecules surround the sodium and chloride ions when water and salt is mixed. The negatively charged end (oxygen atom) of the water molecule bonds with the positively charged sodium ions, while the positively charged end (hydrogen atoms) of the water molecule bonds with the chlorine ions. “Like dissolves like”: polar solvents such as water dissolve polar molecules. Polar molecules are hydrophilic such as sugar, salt and ions. Non-polar molecules, such as fats and oils, are hydrophobic and do not dissolve in water. Fats and oils are mostly made up of carbon and hydrogen. Most chemical reactions occur in a water solution.

C. Water regulates Temperature

Water helps to regulate temperature in organisms because it resists temperature change and evaporation. The many hydrogen bonds that link water molecules together help water absorb heat without a great change in temperature. Water has a high heat capacity and its temperature drops more slowly than other liquids, organisms are able to maintain their normal body temperatures and are protected from rapid temperature changes.

Water evaporates at a high temperature which enables animals in a hot environment to release excess body heat in an efficient way. During sweating or cooling under a sprinkler, body heat is used to vaporise the water, thus cooling the animal or individual. During summer oceans absorb solar energy and store heat, then releases it slowly during winter.

Ice is less dense than liquid, thus ice floats on water. This property of water - also due to hydrogen bonding - prevents lakes and ponds from freezing completely. The heat is trapped under lakes to protect aquatic life in freezing weather.
**Table 1: The Rubric for marking the Concept Map**

What **Figure 3** shows is one of the answers as a sample of what first-year students are able to produce even under exam conditions.
Figure 3: An exam answer using a concept map

In the example given, 55 students (out of the 211 that wrote the exam) chose to do this question. Of those 55, 45 achieved between 50% and 80% (see Table 2). The 10 students who failed the question achieved between 0% and 45%. Table 2 shows the range of marks achieved for this question. A pass mark is 50% (or 5 out of 10). Of the ten failures, one student did not produce a concept map, but misread the question and wrote a paragraph instead, so scored zero. Another failure was due to an inability to connect any of the concepts identified (30%). The other eight students got between 40% and 45%, primarily because of insufficient identification of the major and subsidiary concepts.

Of those who passed, or who were competent at creating and using concept maps, each could improve; such increased sophistication could be expected to come with more practice. These results give us hope that the technique could achieve success as a teaching tool.

<table>
<thead>
<tr>
<th>Percentage achieved</th>
<th>Student numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 30</td>
<td>2</td>
</tr>
<tr>
<td>40 – 45</td>
<td>8</td>
</tr>
<tr>
<td>50 – 55</td>
<td>15</td>
</tr>
<tr>
<td>60 – 65</td>
<td>17</td>
</tr>
<tr>
<td>70 – 75</td>
<td>11</td>
</tr>
<tr>
<td>80 – 85</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 2: Mark ranges for exam concept maps
The real reasons for this variation in concept map quality are unclear and would require further investigation. Until such analysis is done, it is also not clear whether the inclusion of concept maps for summative assessment is a reliable indicator of understanding. This observation notwithstanding, the general indication is that creating the concept maps enabled students to have an overview of the sections to be covered, to see the correlation between the textbook and the lectures, and to transform text into a visual representation which facilitates study and summarising skills.

A survey of students’ views of concept mapping was conducted with the twelve students who volunteered to complete the questionnaire. This was intended to give us an impression of their understanding and use of concept maps. The survey (see Figure 4) covered their ability to create concept maps and what the benefits and difficulties were.

**Student survey on concept mapping as a learning technique**

Please answer the following questions as fully and clearly as you are able. Please be also absolutely honest in your responses.

1. Did you find creating concept maps in LFS151 helped you understand better connections between concepts studied? Circle the appropriate number.

<table>
<thead>
<tr>
<th>1 – not at all</th>
<th>2 – a little</th>
<th>3 – fairly ell</th>
<th>4 – very well</th>
<th>5 - excellent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
2. Did you find creating concept maps easy or difficult?

<table>
<thead>
<tr>
<th>1 - very hard</th>
<th>2 - quite hard</th>
<th>3 - reasonable</th>
<th>4 - easy</th>
<th>5 - very easy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

3. Were you able to use concept maps to study better? Explain your answer.

____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________

4. What was the most useful aspect of using concept maps?

____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________

5. What was the least useful aspect of using concept maps?

____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________

On the understanding that my name will not be used and my results remain anonymous, I give permission to Ms Short to use these answers in her research on concept mapping as a learning tool:

Name: _____________________________ St. #: __________
Signed: __________________________

Figure 4: Student Survey
In the responses, nine of the twelve students who answered were positive and able to identify why concept maps had been useful. As one student said, ‘I think every aspect of using a mind map was very useful to me. For example if I studied for a test without using a concept map, I wouldn’t do well as compared to when I used it’ [sic]. Although nine of the twelve respondents felt it was useful, only four felt that concept maps were relatively easy to create. The others struggled because it was time consuming or difficult to know where to begin. In addition, some had trouble with spatial organisation, identifying the key words or naming the relationships, and then were unsure which were hierarchically more important. Two of these students felt quite unable to construct the maps without a lot of assistance and guidance and one simply was not prepared to try this ‘new’ strategy, saying, ‘I never used them and they didn’t help me because the technique was new and I couldn’t adapt to it. I was fixed to own style of studying and didn’t try it at all.’

CONCLUSIONS AND CHALLENGES

To accept the premise that the majority of students who are admitted to the ECP at UWC come from educational and social backgrounds that compromise their success at university (for the range of reasons mentioned in the discussion above), is to acknowledge that they will require something different in a teaching and learning approach from what has been on offer to date. This is manifested in their need to be given more than the usual support provided in the Life Sciences, both to gain epistemological access to the academy and to succeed in their chosen field of study. For this reason, concept maps were introduced as one tool that could contribute positively to their desired success. Factors that are barriers to that success include the difficulties of studying much larger volumes of content than they did at school level; being obliged to use the linguistically challenging language and presentation of study material in their prescribed American textbook; holding inadequate or confused conceptual understanding; and being poorly equipped with efficient study methods.

To manage the complexity and quantity of biological material covered in their first two years of Life Science at UWC, students need to have a firm
basis of accurate conceptual knowledge. We believe that the benefits for students of using concept maps include the facilitation of using the prescribed textbook as a resource, getting a clearer overview of the sections of work covered and how the concepts therein are related. This can then benefit the students’ grasp of essential concepts, thus reconfiguring any earlier misconceptions. We also see concept maps as providing a transformative tool for synthesising known and new knowledge which is personally or collaboratively constructed, either in class or when studying alone. The benefits to the lecturer include the provision of a quick tool for identifying areas of confusion; the enabling of a relatively quick and often immediate response to that confusion; the facilitation of discussion; the introduction of interactive teaching; the identification of what major concepts need to be taught; and the provision of a valuable framework for teaching and assessment.

Although concept maps were introduced only nine months before the survey referred to above, it must be acknowledged that there are challenges to be faced. Certainly, the apparent benefits indicate that it is worth continuing to use this technique and to expand its use in some of the many ways suggested by Novak (2008). It is also worth noting that this is but one tool amongst many and does not simply replace the many other ways of teaching and learning.

One of the challenges is that learning to construct sound concept maps is not a quick process – both staff and students have to be prepared to give time to develop the skill. Facilitating the discussions and negotiating the choices of words and connectors is a creative process and so requires flexibility by the lecturer, while yet maintaining a clear picture of the whole. Students need assistance to get better at seeing the key concepts and labelling them to make overt the connections between them, these being particularly difficult aspects of constructing the concept map (Novak, 2008). Reaping the full benefits of concept maps requires considerable practice and discussion of alternatives. Even agreeing on what is major, what is subordinate and how these concepts are arranged is negotiable, but congruence of thinking comes over time and with discussion. That said, concept mapping may well not suit some learners, not only because of
learning styles but because the shift of style is in any case different, causing what Hayes et al call a ‘period of “disjuncture’” (2008), when students are still struggling to manage this new technique of knowledge construction.

Before beginning to teach, there should be collaboration between lecturers who work in the same field to ensure that there is consensus about the major issues. It is to be expected that there may be remarkably different views on what are central concepts for subject content focus, which leaves some uncomfortable at first. Finally, as the students in the survey indicated, some students struggle to make the paradigm shift, especially those successful at more linear forms of organisation and study.

REFERENCES


THE VALUE OF SERVICE LEARNING AS A TEACHING TOOL IN ECP

Suné St.Clair Henning

ABSTRACT

Service learning is a course-based intervention whereby students participate in a structured community service project. Through integration of theory and practical application, service learning could provide a means for students to learn how to become a participant in an academic discipline and could provide a means to epistemological access.

The Department of Food Technology at Cape Peninsula University of Technology (CPUT) initiated a service learning project (Trout Harvest Processing Technology Project) in 2010 with second year Extended Curriculum Programme (ECP) students. The main objective of this service learning project was to strengthen the ability of students to integrate everyday knowledge with academic knowledge; and with the second aim of addressing the need for training informal small-scale trout farmers (the community) in basic food hygiene, personal hygiene, food safety, and post-harvest processing technologies. This service learning project assisted students in the ECP programme in understanding how the theory from different subjects in Food Technology is used to address challenges in the food industry. It may thus be argued that service learning can facilitate students in learning how to become an active participant in the practice of Food Technology, providing a route toward gaining epistemological access. This paper outlines a case study where service learning is used as a pedagogical tool in assisting students on the ECP programme in Food Technology to gain epistemological access.
INTRODUCTION

Service learning plays an important role in strengthening the third pillar of Higher Education, which is community engagement (Hlengwa, 2010). The other two pillars of Higher Education include teaching and research. In service learning, students do meaningful service in a community setting while gaining educational experiences related to theory and personal growth. Ash and Clayton (2004) describe service learning as being ‘a collaborative teaching and learning strategy designed to promote academic enhancement, personal growth, and civic engagement.’ Bringle and Hatcher (1995) mention the credit bearing aspect of service learning in their definition: ‘a credit bearing, educational, experience, in which students participate in an organised service activity that meets identified community needs and reflect on the service activity in such a way as to gain further understanding of course content, a broader appreciation of the discipline, and an enhanced sense of civic responsibility’.

Morrow (2009) suggests that, to learn how to become a participant in a particular academic discipline, one needs to gain epistemological access. Morrow further argues that epistemological access is gained by what the individual student does; the teacher can only facilitate a student’s epistemological access. Brownlee et al (2009) talk about personal epistemological beliefs, beliefs which are held by individuals about the nature of knowing and knowledge, and found from their study that there is a relationship between core beliefs of knowing and peripheral beliefs (beliefs about learning).

The term ‘ECP students’ refers to students on the one-year Extended National Diploma in Food Technology course at CPUT. These students follow the same course curriculum as the mainstream students, however, semester subjects are extended to year subjects, thus allowing lecturers to give the ECP students additional support in learning. Additional support may include several teaching and learning activities, for example extra tutorials and practicals to demonstrate a specific concept, food-factory visits, making use of clickers in the classroom, assigning tutors and mentors to at-risk students,
and class assignments. One such a support activity on the ECP Food Technology programme is where second year ECP students participate in a service learning programme. This paper describes how the participation of students in a community service project may provide a route for them to gain epistemological access.

**PROBLEM STATEMENT**

In general, Food Technology students, especially at first-year level, do not fully understand the ‘bigger picture’ of why they need to study different subjects, some of which are only indirectly related to the discipline of Food Technology. At first-year, and even second-year level, most students are unable to integrate horizontal and vertical knowledge, mainly due to lack of practical experience in the field of study, but also due to failure to adopt the Food Technology ‘culture’ or academic discipline (Morrow, 2009). Morrow discusses in detail the concept of learning how to become a participant in an academic practice and argues that to learn the intrinsic disciplines and constitutive standards of a practice is a long-term project and involves not only ‘self-study’ but also facilitation from those who already understand the practice. For an ECP student to become a participant in the academic discipline of Food Technology might take longer than a student on the normal programme (mainstream students) since their programme is extended by an additional year. Students in the Food Technology ECP programme complete basic science related subjects in their first year and in the second year continue with first year (second semester) subjects. As a result of this, these ECP students might still feel ‘lost’ and not adapted to the Food Technology discipline when they continue to the second and third year, where they join the mainstream students on the normal programme.

By involving second year ECP students in a service learning project, the bridge between subject theory and relevance to the Food Technology discipline can be crossed in a very practical and rewarding way. The Trout Harvest Processing Technology Project was initiated in 2010 as a community service and capacity development project, with one of its aims being the empowerment of women. Since service learning involves student
participation and learning, it was identified that the second year ECP Food Technology students would be perfect to be part of this project, firstly because their schedule is such that it slotted in with the service learning project being a year project, and secondly they had first year knowledge which could be drawn into the ‘course material’ for this service learning project.

As part of the Trout Harvest Processing Technology Project students have to present course work at a one-day workshop to small-scale trout farmers. Topics addressed include introduction to fish processing, basic hygiene in food processing facilities, food quality, food safety, and trout farming and hygiene.

The outcomes of the Trout Harvest Processing Technology service learning project included:

1) Supplying indirect assistance to informal small-scale trout farmers in becoming a sustainable supply of high quality trout by hosting a one-day workshop during which technical information, knowledge, skills, and examples of basic food hygiene and food quality were emphasised,

2) Giving Food Technology second year ECP students the opportunity to gain hands-on experience of the food industry and to improve their communication and learning skills. The main focus of getting students to participate in the service learning project is to facilitate them in gaining practical experience by working in groups, and also individually, and in applying the fundamentals they learned in first year Microbiology and Chemistry, and second year Food Legislation and Food Technology to a real-life project while students felt that they were making a contribution to the community’s needs. Ropers-Huilman et al (2005) give a good example of this where the authors describe the value of service learning as pedagogy for meeting learning objectives in an engineering course.
The above mentioned outcomes clearly indicate that service learning is a two-way process which strikes a balance between ‘service’, which occurs in the community, and ‘learning’, which enriches the understanding of course material among students (Hlengwa, 2010) and strengthens the combination of theory and practice.

INNOVATION IN FOOD TECHNOLOGY LEARNING

Hands-On Co-operation, initiated in 2004, was a result of a Rural Aquaculture Development Programme at the University of Stellenbosch with the Division of Aquaculture and National Department of Science and Technology. The objective of the Hands-On project was socio-economic development of farm workers (wine, fruit and olive farms) and rural communities from a previously disadvantaged background. The Hands-On project provided job opportunities and sustainable economic development by giving farm workers the opportunity to become a small-scale trout farmer (running his/her own business) and thus a member of Hands-On Co-operation. A small-scale trout farmer is responsible for running his/her own trout-farming business, with permission from the farm owner to make use of the private or state-owned dams. The responsibilities of small-scale trout farming are completely outside the usual responsibilities of the farm workers on the farms.

Under the Rural Aquaculture Development Programme, all small-scale trout farmers have received basic training in aquaculture, business skills, and life skills. However, it was identified that these small-scale trout farmers require basic training in food hygiene and safety, since they are one of the main suppliers of fresh trout to several fish processing facilities throughout the Western Cape region. Any food processing facility has specific product specifications in terms of food quality and food hygiene. Therefore, if the trout supplied by the small-scale trout farmers do not meet the specifications of a specific food processing facility, the fish will not be accepted, and the trout farmers will be turned away, either to find an alternative buyer for their fish, or simply to run the risk of losing all their fish since they do not have refrigerated storage facilities of their own. It was thus identified that training
in basic food hygiene and safety, as well as personal hygiene, would assist the small-scale trout farmers to produce and supply high quality trout.

Students were introduced to the Trout Harvest Processing Technology service learning project by being informed of the main aim of the project, i.e. that they would be presenting a one-day workshop to informal small-scale trout farmers as a means of doing a service to this community. Students were then given formal lectures on the theory and on aspects of the course material (specifically designed for the one-day workshop) that they would have to present at the workshop. Although these formal lectures provided students with new academic knowledge related to the post-mortem quality and processing of fish, they also assisted the students in applying the fundamental theory of Microbiology they gained in their first year as Food Technology students to the practical aspect of this project (i.e. factors influencing the quality and spoilage of fish).

In addition to formal lectures, students were given class activities and assignments which combined the theory with the practice. Class activities included site visits to several of the small-scale trout farmer communities (Figure 1), as well as fish processing facilities (Figure 2), with the aim of exposing the students to the practical side of the project. In guiding the students to make the necessary connection between the academic theory and the service activity (Hlengwa, 2010), student reflection was accomplished through formal written assignments and reports, classroom discussions, PowerPoint presentations, and post-survey questionnaires. These activities facilitated students’ ‘self-directed’ learning.

**Fig. 1:**
CPUT Food Technology second year ECP student visit to small-scale trout farming cages at Jonkershoek, Stellenbosch, where the students were taken on to the dam to view the farmed trout in the cages.
As preparation for being chosen as course presenters, students had to design their own PowerPoint slides from the course manual, research additional theory from textbooks and attend factory visits in relation to the topics to be presented at the one-day workshop. The activity of preparing to make a presentation in front of an audience forced students out of their comfort zones and built up their understanding of the underpinning theory of basic Microbiology, Chemistry, and Food Technology. The students were then given the opportunity to present their PowerPoint presentations in class, during which they were evaluated by the lecturer and by their peers; this covered the credit bearing aspect of the service learning project. The better presenters were chosen to fulfil the role of course presenters at the one-day workshop, while those not chosen had the responsibility of acting as translators during the one-day workshop (since many of the small-scale trout farmers are not fluent in English). In order for students to be chosen as course presenters, they clearly had to obtain deeper understanding of the course material, theory and topics so that they would be able to explain it to delegates at the one-day workshop.

During the one-day workshop, students were also responsible for assisting the small-scale trout farmers in completing a course evaluation questionnaire (Figure 3).
Fig. 3: CPUT Food Technology second year ECP students presenting course material and engaging with the community at the one-day workshop in Stellenbosch by assisting delegates in completing a course evaluation questionnaire.

EVALUATION AND FEEDBACK

Student progress was monitored in the form of formal written assignments and reports, classroom PowerPoint presentations, and continuous feedback reports of each site or factory visit. These activities contributed a weight of 10% toward the total and final mark for the subject Food Processing Engineering, which is one of the subjects the second year ECP students have to complete as a year module.

However, students were also asked to reflect on the experience they gained from this service learning project. Ash and Clayton (2004) describe the importance of self-reflection within a service learning project. Self-reflection should enhance personal growth and help students with connecting their experiences to the theory of the project. This further strengthens Morrow’s argument that in order to gain epistemological access, some academic practices (for example Food Technology) depend on what am I doing, and how am I learning (Morrow, 2009).
Self-reflection feedback from students indicated that being part of the service learning project gave them the opportunity to improve on communication skills, not only to stand in front of an audience as a presenter, but also to explain concepts of basic Food Technology to non-student fellow members in a simpler way. Some of these student comments are given here below:

‘Gained confidence in public speaking during presentations.’

‘I learned how to talk in front of a large audience and how Food Technology is important in our lives.’

‘Trying to reach out to people who are not on the same level is not as easy as trying to explain something to my fellow students.’

In accordance with a study conducted by Dicklitch (2003), this service learning shows the relationship between theory and the real world and forces students out of their cultural, economic, and social comfort zones and encourages them into ‘deeper learning and understanding of the academic field they’re enrolled into’. This further strengthens the argument that service learning may provide facilitation towards gaining epistemological access (Morrow, 2009).

Another outcome from the students’ viewpoint is that this service learning project made them understand the importance of deeper understanding of course material before one can apply it in practice. Some of these student comments are given here below:

‘How some of the things we study at Tech are applied in the world. The fact that communication is very important in the food industry and that you
need to know and understand what you talk about.’

‘The way trout is made into smoke fish. The role of Food Technologists with the process and HACCP systems.’

The above-mentioned statements given by the students indicate that students recognise the importance of self-directed learning and that there exists a relationship between epistemological beliefs and the constructivist conception of teaching and learning (Otting et al, 2010).

Feedback from the community indicated that small-scale trout farmers valued the one-day workshop and requested that it be repeated in 2011. With the success of the service learning project in 2010, the same project was repeated in 2011.

**CONCLUSIONS**

Service learning focuses on community engagement and active learning. Both of these involve student participation to such an extent that service learning promotes pedagogical discourse, strengthening the ability of students to integrate vertical with horizontal knowledge, and self-directed learning and thus may promote epistemological access. Student feedback from the 2010 ECP group indicated that the students, besides gaining meaningful learning and functional knowledge, gained enjoyment and personal growth during this form of active learning and recognised the importance of self-directed learning.

Service learning can thus provide ECP students with the additional teaching and learning support they require to become successful learners and graduates. When service learning involves students in active participation and guided reflection on experience, and when it puts them in a position where they have to take responsibility for their own performance (public speaking), it can also facilitate independent understanding and assist
students to produce knowledge in their field, thus becoming part of the Food Technology discipline.

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UNDERSTANDING LIFE SCIENCE BY MODELLING THE MOLECULAR WORLD: 3D MODELLING ACTIVITIES ENABLE ACCESS TO ABSTRACT CONCEPTS.

Cynthia Slattery

ABSTRACT

The argument in this paper is that Extended Programme students can begin to learn abstract concepts and make meaning when they are given opportunities to interact with peers and the teacher during 3D model building activities in the classroom. This begins to give these students epistemological access to specific knowledge that they are required to master. This argument is based on the theory of constructivism whereby student learning is mediated by the teacher and peers in a social context and students learn by going from known ideas to unknown ideas. Students are given opportunities for questioning and discussion while building models and in so doing to start accessing concepts.

A qualitative, auto ethnographic method of research was used to analyse and reflect on a specific teaching and learning case. A review of the literature indicates that using models helps students to begin to talk about and ask questions about specific knowledge, and also gives students a non-linguistic representation of certain knowledge which may help them to remember material better.

Everyday items were used by students to construct 3D models. This strategy was chosen to help with knowledge construction for certain topics in cell biology in the first year Life Science module. This learning strategy was designed to help to explain some difficult concepts that are at the molecular and microscopic level.
Case studies of Epistemological Access in Foundation / ECP studies in SA

This case study shows a way to give epistemological access to Extended Programme students by giving them a physical structure to work with, that could help with their conceptual learning. The teacher becomes the interpreter, using models to show links between the theory in the class and 3D interpretations of these ideas. Students learn and practise valuable skills while building models – they pose questions and discuss the problem at hand and in so doing begin to talk about the work that they need to learn. This case reflects, in a narrative way, on the context in which certain subject matter was taught, and how the teaching and learning took place. The teacher benefited from the reflective practice in order to better understand how learning takes place in a particular situation and how this insight can be used in future teaching.

INTRODUCTION AND CONTEXT

In this paper, I argue that one way Extended Curriculum students can access Life Science knowledge is by being provided with an opportunity to talk about their work and pose questions. This can be done by building 3D models using everyday items. These models allow access to particular types of knowledge in Life Science, a position based on the view that scaffolding thinking in a particular way allows access to particular knowledge.

Epistemological access is access to the ways of constructing knowledge in various disciplines (Morrow, 1993: 3). Making scientific models is one way of allowing access to a way of thinking and showing what kinds of knowledge is valued in life science.

Using an auto ethnographic research method I will explain and reflect on what I did. I was employed by University of the Western Cape Dentistry faculty to scaffold learning for a group of students who had failed their Life Science module. I tried to find a way of making particular content more explicit and thereby beginning to give my students epistemological access to new knowledge. In this module, the subject matter had originally been introduced to students in a large-lecture format which was problematic, as it was not conducive to conceptual learning, especially for certain students, as they may not have gained all the necessary content. This situation also
did not allow for asking questions, discussion or reinforcement of the material. One of the strategies that I have used is to get students to build 3D models in groups during class time.

I saw my role initially as getting students to pass tests and exams in this module. Students require specific strategies and ways of approaching the content that will explicitly show them what was important to know and what to leave out. Students with help from me, the teacher, are able to begin to formulate ways to master the relevant content and be able to apply it to new situations, for example questions in an exam or test. The structures of particular molecules are valuable content that will open the doors to more complex content and to the understanding of more complex processes.

Some of the epistemological challenges were explaining difficult content and invisible processes to Extended Programme students. I have come to realise that true learning only happens when students know how knowledge is created and structured and then how to interpret the content. This realisation was caused by the fact that I started attending teaching and learning workshops, started talking to other practitioners about their situations and ways of coping and began reading about how to teach particular parts of the curriculum.

My introduction to the large body of education theory, including Bernstein (that students’ backgrounds and language or discourse affects their learning), Vygotsky (mediated learning and zones of development), Morrow (epistemological access), McKenna (access to a new tribe and a new group at university) – the ideas of social constructivism, and developmental psychology (Piaget), has helped me to begin to understand that learning is complex and teaching is best done when I am thinking deeply and trying to assimilate these diverse ideas of learning.

My readings have shown me that education theorists view learning in different ways and this has begun to assist me in finding out if I was teaching in a productive way or just giving out information! I did not want my lessons to be boring so I searched for innovative ways to present the material. The students were uneasy about being in the Extended Programme and I was
aware that although they had failed their exam, the content was known to them in some respects. I felt that particular content required reinterpretation. Using different methods would help students to see where they had misinterpreted or misunderstood the content. I wanted to make new meaning for students using 3D models for representing molecules, structures and processes. Text and diagrams were used to reinterpret particular content with the students during particular model building activities in the classroom. Students learn more when knowledge is constructed around known parameters, using everyday items helps with this learning.

Invisible molecules and cell structures are not in the everyday realm of students’ experience. These invisible ideas and concepts need to be made accessible to students by making them bigger to the eye and then by being able to manipulate them (Herman et al 2006: 248.). Tactile models give students an opportunity to do this (Marzano et al, 2001: 72). This case study shows that by visualising and making models of microscopic structures, and by asking many questions during the building process, students can begin to construct knowledge of the abstract and begin to gain epistemological access to this knowledge.

To help students gain better access to abstract knowledge, 3D tactile models were made to illustrate two concepts in the first year Life Science module. Students in the Extended Programme learn more from concrete representations of microscopic phenomena (Moreno et al, 2011: 32). These students find it difficult to learn abstract concepts. Learning with models is active and tactile. This reinforces the notion that it is what the student does that is important to further learning (Biggs, 1999: 59). The student talks to the teacher and to peers while making the model. It is in the talking, the question formulating of students and teacher questioning students that new meaning can be made of complex concepts.

Biggs (1999: 60) defines learning as ‘a way of interacting with the world’. He goes on to say that as we learn, our ideas about things change and we see the world in a different way (Biggs, 1999: 60; Hardman and Ng’ambí, 2003: 139). In the situated cognition version of constructivism, learning is defined as ‘a process of enculturation or individual participation in socially organised
practices, through which specialised local knowledge, rituals, practice and vocabulary are developed’ (Hennessy, 1993: 2). This means changing from one sociocultural context to another, from everyday context to scientific context, that is changes from the practice of one culture to another (Corber and Aikenhead, 1998: 18, McKenna, 2010).

Teaching for access

Learning in the Life Science module presents particular challenges for Extended Programme students. Being able to break down microscopic cell structures and processes to the molecular level is the learning challenge. As learners we search for tools to help us understand our experiences and we synthesise new experiences into what we have already come to understand (Brooks and Brooks, 1999). This is the basic notion of constructivism. In building models students are given the opportunity to begin to understand a new experience.

Brooks and Brooks (1999: 37) state that ‘interaction with a piece of equipment offers immediate feedback’ – a ‘hook’ for many students to attach new information to. Making models with a class can do this. The attributes of a constructivist teacher are discussed in Brooks and Brooks (1999: 103-108). The important notions for this discussion are that constructivist teachers:

1. Encourage and accept student autonomy and initiative. This can be done while students make a model together. Students can choose how they wish to represent a particular part of a model.

2. Are important to student learning and to seeking to understand a student’s point of view as the teacher acts as a mediator in this learning. The teacher can guide the model building process.

3. Enquire about students’ understanding of concepts before sharing their own understandings. The teacher can use a model building activity to find out what students know and then can introduce new knowledge.
4. Encourage students to engage in dialogue between the teacher and one another. Model building can give students an opportunity to do this. Brooks and Brooks (1999: 108) note that a powerful way students come to reinforce conceptions is through social intercourse and having the opportunity to give their own ideas, and being able to hear and reflect on the ideas of other students helps the process of making meaning.

5. Encourage student inquiry by asking thoughtful and open ended questions encouraging students to ask questions of each other. Biggs (1999: 60) maintains that students need to be active in a learning context and that meaning is created by these activities. In the modelling activities students are actively asking questions as they try to make sense of a diagram which they are to interpret into a 3D structure. The teacher’s role becomes that of interpreter or mediator, showing the links between the abstract and the concrete aspects of particular concepts (Ealy, 2004: 462; Brooks and Brooks, 1999: 37).

Epistemological access is access to the ways of constructing knowledge in various disciplines (Morrow, 1993: 3). Making scientific models is one way of allowing access to a way of thinking and showing what kinds of knowledge (such as precision and detail) are valued in Life Science. Learning can further take place when problems are mediated under the guidance of adults, e.g. a teacher or capable peers as in Vygotsky’s theory of the zone of proximal development (Vygotsky, 1978: 90). Making specific knowledge more obvious, within the new social context of a scientific discipline at a university, is what I hoped to achieve in this Foundation Life Science module.

Students are to be made aware in a more obvious manner of what knowledge is important in science and what is required as far as their academic literacy development is concerned. Science is defined in the following way by Gottlieb (1997: 2) as
an intellectual human activity that is concerned with integrating and coordinating, in a systematic way, new information with an existing and ever expanding reservoir of information. This integrating gives a more complete description and explanation of the natural world in which humans live and this information is organised into meaningful patterns.

Gottlieb (1997) goes on to add that, when they integrate information, scientists are creating more complex patterns of relationships between and amongst the various pieces of information; they are establishing higher degrees of order of knowledge. The higher degrees of relationships, in many cases, actually simplify understanding the knowledge base by making it easier to understand seemingly unconnected pieces of information. These higher orders of relationships are called theories, principles, and laws.

Making models can be viewed as a way of integrating information and connecting seemingly unrelated ideas and showing relationships between them, and by this means they begin to make meaning for students.

While academic literacy is described by McKenna (undated) as

The ways in which students must read, write, speak, listen, even be, for success in the University. To be academically literate is to be proficient in the way in which knowledge is constructed within the discipline.’

McKenna (2010: 8) maintains that

academic literacy is seen to be related to specific cultural contexts and if our students do not share our background knowledge, values and attitudes, successful meaning making is impossible.
The challenge with teaching Life Science to new students at university is the nature of scientific knowledge.

Life Science knowledge that has been taught at school level is mostly a summary and simplification of what science is. For example Anderson (2003: 9) suggests that school Science does not give most students a deep understanding of fundamental science, instead he says they end up with a ‘shallow understanding of fragmented facts and skills’. School Science, he goes on to explain, often separates knowledge and skills and rewards procedural display (doing what the teacher says in order to get a grade). This is in contrast to scientists' science which aims to make sense of the world by finding connections among patterns, evidence and explanations. Telling the story involves organising and explaining scientific knowledge in a coherent way.

This is what I was aiming to give my students to do when giving them models to build. By this means students have been given the opportunity to express their knowledge verbally and in non-linguistic terms, while finding ways to represent particular structures in a model, and in so doing to try to organise knowledge in a particular way.

McKenna (2010: 8) suggests that all knowledge is socially constructed rather than ‘found’, and that students need opportunities both to understand the context in which particular domains of knowledge are constructed and to construct knowledge in these ways themselves.

Morrow (2007: 18) contends that access here concerns access to teaching practice and learning strategies and discourses that enable students, many from a background of schooling that has not prepared them well for university study, to learn the kinds of things universities teach. Teaching is an activity guided by the intention to promote learning and takes into consideration the current epistemological condition of the learners, and the possibilities of success of the various teaching strategies are also taken into
account (Morrow 2007: 20). In the case of this paper, using models is the chosen strategy.

Epistemological access is also fostered by the purposeful inclusion in learning activities of the skill of questioning. Asking students questions helps them begin to grapple with difficult concepts, e.g. the structure of a cell membrane that one can only see under a microscope. This discussion happens when a learning activity is able to allow this questioning to take place, for example when students are put into a group and are asked to build a model. The model building becomes a problem solving activity, and questioning skills are vital in order to solve the problem of building a model.

Epistemological access is also promoted when a teacher asks questions during the model building exercise. This allows the teacher the opportunity to give immediate answers and correct possible misconceptions as they arise. Students asking questions is a very useful indicator of what assistance the student needs (Hardman and Ng’ambi, 2003: 140).

Social constructivism emphasises how meanings and understandings grow out of social encounters (Atherton, 2011). In the classroom this approach includes experiential activities such as building 3D models (Laliberte, 2005). Constructivism suggests that the learner is more actively involved in a joint enterprise with the teacher of creating new meanings (Atherton 2011). While we take in some knowledge passively, the constructivist approach suggests that even this information needs to be mentally acted upon in order to have meaning for the learner (Brooks and Brooks, 1999).

1. **Disciplinary knowledge**

The use of 3D models helps learners link their knowledge to the new scientific knowledge being learned at university, making hierarchical and content knowledge more accessible. Models simplify certain concepts and make particular knowledge more accessible; for example, by building a model of a protein the students are able to see how the molecules are joined together and how they are packaged to fit into a cell for particular functions.
Wheelahan (2007: 10) suggests that students need to be introduced to the content as well as the structures of knowledge in a particular discipline, because students need to learn this new content so that they will be able to apply it to new situations, and knowing how this knowledge comes about, how it is put together, is important to their own structuring of knowledge. She contends that access to disciplinary knowledge is important for epistemological reasons as it provides students with access to the ‘collective representations’ about the causal mechanisms that the discipline studies, mechanisms that are not always accessible through direct experience.

Muller (2000) contends that the disciplines provide students with access ‘to the disciplinary style of reasoning’. Disciplines do this by introducing new students to the discipline’s particular way of doing things in the way they conduct their knowledge acquisition, that is, how they conduct research and compile their findings. Wheelahan (2007: 10) goes on to say that students need access to generative principles, and need to understand knowledge-structuring processes and how complex bodies of knowledge fit together, if they are to decide what knowledge is relevant for a particular purpose, for example how the Life Science knowledge is put together in a curriculum, beginning at the atomic level and moving to the level of organism.

2. **3D model use theory**

3D models have been effective in introducing students to abstract concepts (see Patro, 2008; Ealy, 2004; Francœur, 1997 and 2000; Gilbert and Boulter, 1998). Marzano et al (2001) argue that the use of non-linguistic representations of knowledge not only helps students understand the material better, but also enables them to remember it more easily. Herman et al (2006: 247) state that, while teachers aim to give students a deep understanding of fundamental concepts underlying (for example) protein structure and function, this is often done by exposing students to static, two-dimensional graphics of proteins in textbooks, and with interactive images that can be rotated in three-dimensional space on a computer. This approach does not enable under-prepared students to make certain inferences. For them, the molecular world of proteins remains an abstraction.
This approach is successful for those students who are able to infer three-dimensional information from these two-dimensional representations.

Herman et al (2006: 247) have found that physical models of proteins are effective tools that capture the interest of students and motivate them to learn more about the invisible, molecular world. When a student rotates a physical model in his or her hand rather than in his or her mind, Herman et al (2006) argue, this experience is more likely to open the door to the molecular world of proteins. My students had been given opportunities to make models with peers in class time with my guidance and this is the start of the reinterpretation of particular knowledge.

In the constructivist process, scientific models are valuable tools because they can be used to ‘make sense of abstract, difficult and non-observable science concepts to accommodate the explainer, the audience, the content and the context’ (Treagust and Harrison 1999: 4, in Treagust et al, 2001: 358).

Gilbert and Boulter (1998: 2) describe models as providing a form of visual explanation which helps students link the known and the unknown, the familiar and the unfamiliar. Wu et al (2001) propose a model of visualisation by modifying Paivio's dual coding theory. Humans have separate systems for representing verbal and non-verbal information, consistent with Paivio's (1986) dual-code theory. This is similar to multimedia learning theory which states that the learner has a visual processing system and a verbal processing system (Mayer and Moreno, 1998: 2). Auditory narration goes into the verbal system and animation goes in to the visual system. Mayer's principle of multiple representations holds that it is better to present an explanation in words and pictures rather just in words (Mayer and Moreno, 1998: 3). Model building gives students the opportunity to go from words and diagrams to 3D models to explain particular ‘invisible’ concepts in the Life Science module and this process can involve both verbal and visual displays of concepts.
METHODOLOGY

A qualitative, auto ethnographic approach has been used to study the nature of learning in this case. The author writes a narrative in the first person, making his or her own practice the object of research and the focus is usually on a single case (Belbase et al, 2008: 3). This research method connects the autobiographical and personal to the cultural, political and social context and is characterised by concrete action, emotion, self-consciousness and self-analysis and reflection. (Belbase et al, 2008: 3). I have been reflecting on my own teaching practice.

MY PEDAGOGICAL PRACTICES

The Life Science module is concerned with content about 3D processes that occur at the molecular level and which are invisible to the naked eye. This makes the concepts abstract. Interacting with biological ideas using models gives students an opportunity to get ‘up close’ to what is being taught (Del Re, 2000: 5; Ealy, 2004: 461). The skills of translating and information processing are needed when 3D models are constructed (Ealy, 2004: 462). I did not have equipment, so I used model building, with simple everyday items, to motivate my students.

Firstly, students were required to demonstrate their knowledge of the structure of proteins. They could not always ‘see’ how to make a 2D diagram into a 3D representation. This made students ask specific questions and helped them think more deeply about the task. Getting students to ask question about what they are learning is a valuable tool to ascertain whether they are thinking critically about what they are learning (Hardman and Ng’ambi, 2003: 140).

Taking texts and diagrams and synthesising the information in a model required the use of a range of skills such as identifying what type of knowledge is valued in Life Science; asking questions about size, shape and relationship between the parts also aids students in talking about and summarising the knowledge they are trying to use to build a model. I was
able to ‘see’ how they translated information. This helped me assess what learning had taken place.

Hardman and Ng’ambi (2003: 140) comment that questioning skills are imperative skills to learn for higher order thinking. Model building in the social context of working in a group gets students to ask, for example, how molecules are joined together, what kinds of bonds join the atoms together and what is the orientation of particular molecules to others in complex molecular structures. This helped me, as their teacher, to see where there were gaps in their knowledge. Students were required, for example, to explain the spontaneous folding of proteins. This activity gave students a chance to synthesise concepts, and ask questions about what they had learned in class. Bloom’s taxonomy states that higher order thinking skills are what we as teachers aim for our students to attain. This is a form of epistemological access as we, as teachers, take students from one level to another using particular strategies such as using 3D models to go from content to comprehension and synthesis (Bloom et al, 1956).

Protein structure is important to understand as it is related to how proteins function, e.g. as enzymes in cell membranes. Students were given wire and pencils and an instruction sheet. The students made the primary, secondary, tertiary structures and then explained their models. Students began to relate this activity to the functioning of proteins in cells. I drew a cell membrane on the board and asked them to place the protein that they had just built on to the diagram and they were able to say where it would go.

I extended this activity in the second year of teaching this concept. I gave the students a particular protein to build after the structure lesson. Students had to build an insulin molecule. This gave the students the opportunity to get used to the abbreviations used to represent protein and to practice some of the structures that they had learned in the first protein activity. The students used their knowledge of primary, secondary, tertiary and quaternary protein structures to make the insulin molecule. The activity also included questions about what they were building and linked the study of proteins to the topic of proteins as allergens in food (ehponline.org/science.ed). This assisted students to go from the known to
the unknown concepts in Life Science. The students, with assistance, were able to make their models and were able to answer most of the questions correctly.

Presenting this module has given me the opportunity to try different approaches to models to see what was practical and what worked. Models have made learning active. Using one’s hands to make sense of Life Science concepts has been an important part of students’ learning. Students learn better when they can see the models in front of them.

Secondly, students were given a diagram of the fluid mosaic model of a cell membrane and were asked to make a model using everyday items, e.g. pegs, pasta, wire, seed pods, wool. The models were made on desks and were labelled. The students had to work in groups to make their models. The students began to be able to explain that the globular proteins embedded in a cell membrane have a tertiary protein structure and are in fact enzymes that act as channels in the membranes. This activity was a search for meaning and links and I as the teacher needed to begin the process by asking some specific questions.

The second time I presented this activity I extended it by giving the group information (text and diagrams) about the different transport mechanisms that are used by substances to cross cell membranes. These were to be included in the model this time. As there were only three students in this class they formed one group and designed the model together. I realised as they were making the membrane that they needed more time than I had given them to go over the notes. In future I will give them the notes to read before the activity. Much discussion ensued and I guided the process by asking particular questions as building progressed.

**CONCLUSION**

The models and my students’ reaction to the exercises helped me to conclude that learning abstract concepts needs to be handled carefully. Too much information overloads them and too little information leaves gaps in their knowledge. Using models helps students to begin to interpret the
content in a different way. Students need to be led through the process and the links between the specific content and other representations need to be made very explicit. Extended Curriculum students seem to take much of the information as it is presented. I want them to challenge it a bit inasmuch as they start asking questions about the content. Model building is an interpretive exercise which begins this process. Each activity was designed to give students a better idea of a complex concept. Students asked many questions and were given the opportunity to begin to find out what they did not know and to experience the content in a different way.

3D models of biological molecules and structures provide a tool to use to explain difficult concepts in Life Science. When faced with no equipment, everyday items and some imagination can be used to create a place of learning. This is a practical way of giving a class a means of learning difficult concepts. The intention was to help students with the notion of structure leading to function, which is fundamental in understanding many concepts in Life Science. Each time I have used models in my class, I have learned more about how my students perceive the world of science that I am leading them into. I have been attempting get my students to do what Anderson (2003) advocates – organising and explaining scientific knowledge by ‘telling the story’ through the medium of making models. As I have thought more and more about my reasons for getting students to build models, it has become apparent to me that the real reason I wanted my students to build models was not necessarily to test their building or interpretation skills but rather to enable them to interact with each other and begin to ‘talk Life Science’ in an endeavour to gain new understanding of a section of conceptually difficult work.

I have tried to enable access for my students to a new ‘culture’, the culture of science, and I feel that I have started my students on that journey. These students have thus been given opportunities to express themselves in a non-linguistic way as well as to express themselves verbally while trying to make sense of the subject of Life Science.

I have also seen that I have achieved some of the attributes of a constructivist teacher in that I gave my students opportunities to question
me and each other, in a social context, and in so doing I gave myself an opportunity to understand my students and begin to give them some autonomy to commence their university learning process with insight. I hope that I have given my students a way of linking the Life Science they learned at school to what they are now learning at university.

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BREAKING DOWN THE NUMERACY BARRIER IN THE EXTENDED CURRICULUM PROGRAMME OF THE DESIGN FACULTY IN A SOUTH AFRICAN UNIVERSITY OF TECHNOLOGY

Monika Rohlwink

ABSTRACT

At the beginning of every year, a diagnostic numeracy test is administered to the students entering the Extended Curriculum Programme of our Design Faculty. This case study analyses the results of one such diagnostic test, shows up the fundamental weaknesses with which the students battle, takes note of their reflections on their difficulties concerning numeracy, and then discusses interventions put into place in order to afford them epistemological access to numeracy. The interventions are supported by Vygotsky’s theory of zones of proximal development as discussed by Vockell (2001), as well as the concept of metacognitive apprenticeship as developed by Collins, Brown and Holum (1991). Finally, the summative assessment at the end of the period of interventions is analysed, and a plan of action for the following year is proposed.

(The students’ comments in this paper are verbatim quotes.)

1. INTRODUCTION

Basic mathematical skills are of vital importance in every field of design. Furthermore, the analytical thinking skills developed in mathematics need to
be transferred to problem-solving activities in other areas of life and work, in this case the design disciplines. When this occurs, Vockell (2001, see References) calls this positive transfer of learning. During the annual international Design Indabas held in Cape Town, South Africa, designers stress that practitioners in the various fields of design needed to be increasingly flexible in their chosen field of activity and needed to be prepared, and able, to move across different fields of design. Thus the concept of positive transferral of learning becomes ever more important.

Students arrive at the Extended Curriculum Programme in the Faculty of Informatics and Design, wanting to become successful designers in any one of the following design disciplines: Architectural Technology, Interior Architecture, Fashion, Jewellery, Surface, Industrial or Graphic Design. They have studied Mathematics or Mathematical Literacy at school and, in most cases, have passed the subject. During their Extended Curriculum Programme, they are offered three practical subjects (subdivided into eight modules) and two theory subjects.

This case study is based on work done in the theory subject entitled Professional Business Practice. Because the Extended Curriculum Programme is a preparatory course for entry into any one of the design disciplines mentioned above, my objectives in the Professional Business Practice subject are as follows:

1. Inducting the students into the academic discourse of a Design Faculty in general

2. Teaching them relevant academic skills needed in their next year of studies

3. Wherever applicable, preparing them for the workplace which they will enter after their studies.

Professional Business Practice is divided into Life and Study Skills and Basic Computer Literacy and Numeracy. (Numeracy deals with basic
mathematical skills which need to be mastered in order to be able to do the kind of calculations necessary in any one of the design disciplines.)

Over the past few years I have established that, to varying degrees, our students lack the necessary competencies in these basic mathematical skills. Their practical lecturers have pointed out to me that students are not able to scale up or down in their interior design and architectural projects. They do not differentiate between ratios for adults and for children; they will, for instance, design a theme route for 6 year olds, using a scale for adults. They cannot convert measuring units or calculate surface area and volume. Consequently, I administer a diagnostic test at the beginning of each year to gauge the students’ mathematical competencies. According to the outcome of this test, I develop a series of tutorials to fill in the gaps discovered. This case study deals with the body of students of one particular year.

**RESEARCH PROCESS**

1.1 Diagnostic numeracy test: the point of departure

As soon as the 57 students in the course had settled into the routine of their new environment, they were given the diagnostic numeracy test in which the following areas were tested:

- Elementary geometric shapes and terminology
- Metric conversions
- Accurately measuring dimensions of a diagram, as well as scale conversions
- Solving basic area and volume problems
- A very basic costing exercise (in preparation for drawing up quotations).

The formulae they were expected to know and apply were those for calculating:

- Area and circumference of a circle
• Area and perimeter of a rectangle
• Volume of rectangular prisms (they did not need to know what prisms are).

(Students in Grade 7 and 8 are introduced to these formulae, and, in Mathematical Literacy, these formulae – and more advanced ones – are used regularly through to Grade 12.)

1.2. Analysis of the results of the diagnostic numeracy test

The results in Table 1 indicate the average marks obtained by the entire class.

<table>
<thead>
<tr>
<th>Competencies tested in this question</th>
<th>Q.1: Geometrical shapes &amp; terminology</th>
<th>Q.2: Area &amp; circumference of circle</th>
<th>Q.3: Volume of rectangular prisms</th>
<th>Q.4: Area of rectangles</th>
<th>TOTAL (mark out of 30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ave. mark in %</td>
<td>79 %</td>
<td>33,0%</td>
<td>30,0%</td>
<td>20,5%</td>
<td>40,0%</td>
</tr>
</tbody>
</table>

Table 1: Average marks obtained in the diagnostic numeracy test

The percentages in Table 1 indicate that identifying very basic geometrical elements (diameter, radius, various types of angles, parallel lines) in a sketch or an object (Question 1) was not a problem. However, calculating the area and circumference of a circle (Question 2), volume of regular prisms (Question 3) and area of a rectangle (Question 4) proved to be problematic.
Question 3 (Figure 1) illustrates the level of competency expected of the students. It demonstrates that the questions given were contextualised, and that the ability to apply basic formulae to a composite shape was tested. The students had learned the formula for a rectangular prism (length x breadth x height) in their primary school years. The question now was: would they realise that the volume of one table leg needed to be multiplied by four and the answer then added to the volume of the table top?

**Question 3**

A very expensive solid yellow-wood table (left) has the dimensions as given in the sketch.

a) Calculate the volume of wood used to manufacture this table (in cm\(^3\)).  

b) If the yellowwood needed for the table cost R 25 000, what would be the value of 1 cm\(^3\) of yellowwood?  

c) Now calculate the value of 1 m\(^3\) of yellowwood.

**Fig. 1: Question 3 of the diagnostic numeracy test administered to the students**
Table 2: Further breakdown of marks

Table 2 indicates that only 16 students out of 57 passed with 50% or more. Close to half the class could not answer more than a third of the questions correctly, and only 9 students managed to obtain over 60%.

If one studies the Matric results with which these students came to us, the picture is as follows:

<table>
<thead>
<tr>
<th>Passed with 50+%</th>
<th>16 students (28% of class)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – 10 out of 30 (0 – 33%)</td>
<td>25 students (44% of class)</td>
</tr>
<tr>
<td>11 – 17 out of 30 (34 – 59%)</td>
<td>23 students (40% of class)</td>
</tr>
<tr>
<td>18 – 30 out of 30 (60 – 100%)</td>
<td>9 students (16% of class)</td>
</tr>
</tbody>
</table>

Fig. 2: Maths Matric Results
Case studies of Epistemological Access in Foundation / ECP studies in SA

Fig. 3: Maths Literacy Matric Results

The graphs in Figure 2 and Figure 3 show that the Maths Literacy students obtained very good results, whereas those who had taken Mathematics did not perform as well.

However, there was no particular correlation when one compared the following:

1. The Matric results and the results of the diagnostic test

2. The Matric results and the improvement in performance from the diagnostic test to the official June Numeracy paper.

The following statistics are a fair representation of the findings across the board: of eight students who had received a mark between 50% and 59% for their Matric Mathematics, five failed the diagnostic test with very low marks. Of these five students, four almost doubled their marks in the June examination (after remedial tutoring) and one did not make any progress at all. The remaining three students obtained better marks in the diagnostic test.
than they had received in Matric, and obtained similarly good marks in the June examination.

1.3. **Mathematical problems identified**

The diagnostic test (Table 1) highlighted the following problem areas:

- A general uncertainty about formulae for area and volume

- The inability to convert one measuring unit into another, specifically where areas or volumes were concerned because of:
  - A general uncertainty about the difference between cm² and cm³ (in other words, area and volume)
  - The inability to decide when to divide and when to multiply
  - The inability to apply metric division and multiplication (i.e. when to move the decimal comma to the right and when to the left, and by how many places).

- The inability to apply basic mathematical knowledge to a slightly more advanced problem. The word ‘slightly’ is used intentionally, as the mathematical abilities employed to calculate how much wallpaper is needed for a particular wall minus a large window, are the same as those needed to calculate the area of a rectangle. However, the students had to know that the area of the window had to be subtracted from the area of the wall. In addition, they had to measure the dimensions in the sketch accurately and convert the millimetres into metres. (See average percentage for Question 4, Table 1, above.)

- The lack of verification of one’s answers. Just how serious this lack is becomes apparent when the following answers are considered: it takes 7m (or, in another script: 2,5 cm) of sausage to fill the ‘crammed
crust’ of a 30cm pizza. As a mitigating circumstance the following, and last, observation should be considered:

- The very slow pace at which the students worked. Although the test was marked out of 30, and the students had been given 1½ hours to work through the test, it took the majority of them longer than the set time to complete the test. It may, therefore, have happened that some students did not stop to consider the reasonableness of their answers as they were pressed for time. This, in itself, is a formidable problem as, in the business world, a designer will be expected to work particularly accurately within severe time constraints.

1.4. Students’ perceptions of their problems regarding numeracy

When the scripts were returned to the students and feedback was given, a lively class discussion ensued about the factors which hindered them from performing well. I also interviewed several students on a one-to-one basis to allow them to speak about their difficulties with numbers in a more supportive and safe setting. The following reasons for their poor performance emerged from both the class and the private discussions:

a) Students identified as the most serious problem, the fact that they had never needed to remember formulae as these had always been provided. When I paged through the 2010 Matric Maths Literacy paper, I saw that even the formula for the volume of a basic rectangular container was given: length x breadth x height. This is a formula with which every student from Grade 6 onwards has regularly worked.

b) A close second problem: both the Mathematics and the Maths Literacy students maintained that too much text in a question distracted and confused them. They wanted to be given a task that was clearly stated in predominantly numerical characters. This would trigger the correct pattern in their minds and they would know how to solve the problem. Words obscured the picture, and they were not able to select the appropriate method to be applied.
c) The students made the point that they had been ‘trained’ to answer Matric papers in a particular manner. Matric papers seem to contain a certain range of questions which could be answered in certain ways. Thus the teachers asked their students to work through as many exam papers as possible, using the various methods available to answer the questions. When faced with their own examination paper, students would then recognise the questions and know which route to follow to answer them. Consequently, when I gave them very fundamental problems which did not clearly follow any of these practised patterns, the majority of students were unable to proceed.

d) Finally, many of the students admitted that they had never trusted their mathematical abilities and had no self-confidence when faced with number problems. Some went so far as to say that they grew ‘panicky’ when given a set of problems to solve on their own.

2. INTERVENTIONS: EFFECTING EPISTEMOLOGICAL ACCESS

2.1. Preparing the ‘intellectual ground’

I needed to devise methods of affording the students epistemological access to basic mathematical principles on the strength of the results of the diagnostic test reported upon above, and students’ responses to questions posed to them in interviews. However, I feel that it is necessary briefly to describe several steps I took to prepare the ‘intellectual ground’ before I engaged the students in interaction with numbers.

- **Free writing.** After the diagnostic tasks had been discussed and feedback given in class, the students were given 20 minutes in which to do free writing. They were asked to write about their experiences with, and attitude towards, mathematics, going as far back as they could remember and considering every aspect of their life with numbers: the attitude towards mathematics at home, their Maths teachers, and their successes and failures. They were also told not to worry about spelling,
grammar or sentence structure, but to let their thoughts flow freely. The purpose of this free writing exercise was to allow them to connect with their innermost reactions to mathematics and their past experiences in this subject which had led to their positive or negative attitudes. Elbow (1983: 38) has the following to say about free writing:

By writing down our thoughts we can put them aside and come back to them with renewed critical energy and a fresh point of view. Writing helps us stand outside ourselves.

One student commented:

By admitting about the problems which I have with regards to numeracy and research, I realised that a lot more attention has to be paid and dedication to the particular subjects. Writing about how I studied during my matric final exams made me wonder whether or not it could have been approached differently so that I would have received better marks.

- **The brain and its memory.** Next I gave them a series of three lessons on the brain and its memory, how it works and how we learn. In layman’s terms, I explained to the students the basic features of our sensory, working- and long-term memories. My intention was to bring home to them the following two very important realisations:

  a) Our brain power is inexhaustible, and

  b) it is possible to break down walls, brick by brick, and build new staircases to a better interaction with knowledge (in other words, epistemological access is possible for all of us and can be enjoyed as well).
The following responses of students indicate that this information ‘fell on fertile ground’:

1. ‘It helps build up self-confidence and the ability to explore and learn new things.’

2. ‘Ma’am, you make me feel that I can accept myself and breathe more proudly because you understand my problem and give me hope for myself.’

3. ‘The most thing that I like, Monika, is that you give us hope even though we do badly and that just motivates me to work my best. Thank you’.

• **Metacognitive skills.** Finally, I introduced to them the concept of metacognition and metacognitive skills. The reasons for this are best summed up by Vockell (2001: Ch. 7) when he states:

> If teachers hope to help low-performing students break out of their intellectual imprisonment, they must find a way to help them develop both an automatic grasp of basic skills and effective metacognitive skills to enable self-directed learning.

and

Successful students are aware of, monitor, and control their learning. Central to this knowledge of self and self-regulation are commitment, attitudes, and attention. (the most important metacognitive skills).

If all our students were made aware of the positive control they could have over their own learning activities and could adjust their attitude towards numeracy in particular, then they would approach the numbers game with greater confidence and work towards eliminating old problems. This would allow them to make sufficient progress in
dealing effectively with numerical tasks in their chosen field of study. The following comments, also from students, reflect accurately the generally positive response to this new concept:

Metacognition has now given me a totally different perspective because it can be helpful in situations such as beating your odds and help solving problems.

I’ve never heard of the term metacognitive skills. However, now that I know what it is I will take that knowledge with me long after I’ve finished studies. (our top student).

Finally, I wish to believe that the thoughts expressed below indicate that what I endeavoured to impart in these preparatory classes did resonate with at least a fair number of students:

It has changed the way I will work in the future.

I’ve learned how to think about something and if I actually understand that specific task. This lesson changed my mind on how I see things in life. This creates a new open mind for future projects.

2.2. Re-encountering numbers

Now it was time to take the students back to the ‘beginning’ of their encounter with numbers in order to ‘fill the gaps’ which they and I had identified.

2.2.1 Theoretical Framework

The framework for my method of teaching the students the necessary basic mathematical skills, helping them apply these skills to contextualised
problems, and, at the same time, building up their self-confidence regarding mathematical computations, is based on the concept of cognitive apprenticeship (Collins, Brown and Holum, 1991) and Vygotsky's zones of proximal development as discussed by Vockell (2001: Ch. 4).

Collins, Brown and Holum (1991) sketch the following scene: an apprentice to a tailor would begin by attentively watching his master at work. The master would invite the apprentice to help him and, in due course, allow the apprentice to perform small tasks under his (the master's) watchful eye. These tasks would become ever more important, and the master would begin to step back and let the apprentice work on his own and gain confidence in his craftsmanship. Eventually, when the apprentice had acquired and perfected the necessary skills, and had absorbed and internalised the very nature of tailor, he would be able to practise his trade independently of his master. In the same manner, a teacher could lead a student to independence and confidence in a certain skill or field of knowledge. Collins et al called this process cognitive apprenticeship.

I combined the above concept with Vygotsky's zones of proximal development (ZPD). In her article 'Situated Learning and Cognition: Theoretical Learning and Cognition' (1998), Hedegaard discusses Vygotsky's concept as it is presented in a collection of his writings (Vygotsky, 1987). Vygotsky formulated this concept in relation to school children and the tasks which they could confidently perform under the supervision of an adult or mentor. They would then be given more advanced tasks which would stimulate their cognitive development. In this way they would be taken to ever-higher levels of understanding and mastery.

I used a very basic version of this concept in that our students would be taken back to a point at which they could experience success because they could, independently but under my supervision, apply certain basic methods of calculation. This would give them a sense of achievement and security. Then, with my help, they would approach tasks which demanded slightly more advanced data input ('bytes' of knowledge, as I call it in class) and computational skills. In this way, the students would be led by me, step by step, until they had reached a sufficiently advanced level at which they
could, again, work independently. (Fig. 4 illustrates this outward movement towards independence in the cognitive development of a student.)

For the sake of continuity, I will first describe how I applied Vygotsky’s zones of proximal development to the body of knowledge that needed to be mastered, and afterwards I will explain how I grouped the students during this phase of interventions and offer my reasons for doing so.

2.2.2 Applying Vygotsky’s Zones of Proximal Development in a Numeracy Class

Zone (e): independent, contextualised and successful work

Fig. 4: Illustration of Vygotsky’s zones of proximal development
To give a worked example of how Vygotsky’s zones of proximal development (as per Figure 4 above) were applied as a tool in the ‘intervention’ phase of this study (in order to facilitate epistemological access overtly), the following focus on metric conversions is offered.

In all design disciplines, students regularly have to work with shapes, plans and scale drawings, and all measurements are given in millimetres. It is, therefore, very important that they know how to do metric conversions – and this was one of their greatest weaknesses, according to their own admission and as detected in their diagnostic tasks.

The following discussion refers to the various developmental zones of competencies as illustrated in Figure 4 above.

**Zone (a): most basic and independent competencies:**

At this first level, the following competencies needed to be firmly established in this learning context:

- The students needed to know how many millimetres there are in a centimetre, how many centimetres in a metre, and how many metres in a kilometre. We collectively established that they all knew this.

- They needed to know the difference between a cm (length), a cm² (area) and a cm³ (volume). After some discussion, they were satisfied that they understood these concepts. As support, and to minimise forgetfulness, for instance, about how many mm² there are in one cm² or how many cm³ in a m³, I suggested that they use the sketches below every time they needed to establish the above:

\[
\begin{align*}
1 \text{ cm}^2 &= 10\text{mm} \times 10\text{mm} = 100\text{mm}^2 \\
1 \text{ m}^2 &= 100\text{cm} \times 100\text{cm} = 10 000\text{cm}^2 \\
1 \text{ km}^2 &= 1000\text{m} \times 1000\text{m} = 1 000 000\text{m}^2
\end{align*}
\]
Therefore:

\[ 1\text{cm}^3 = 10\text{mm} \times 10\text{mm} \times 10\text{mm} = 1000\text{mm}^3 \]

\[ 1\text{m}^3 = 100\text{cm} \times 100\text{cm} \times 100\text{cm} = 1\ 000\ 000\text{cm}^3 \]

**Zone (b): added concepts (as per Figure 4):**

The students admitted that they had the following problems: they could not decide when to divide and when to multiply; they did not know whether to move the decimal comma to the right or the left when performing the above-mentioned computations; and they were not sure by how many places the decimal comma should be moved.

**‘Must I multiply or divide?’**

Students did not know whether to multiply or divide by 100 when they were asked to convert cm² into mm². I resorted to visual language and asked them to ‘gather up’ mm² into a cm² to create the impression of arranging a number of smaller units into one larger unit (divide). Then I suggested we ‘explode’ one cm² into mm² in order to drive home the point that one larger unit would produce a number of smaller units (multiply).
Figures 5 and 7 show the examples I gave the students to illustrate how division and multiplication work. Figures 6 and 8 are examples of the exercises they then did.

Exercise 1:

a. 22 R5 coins = ____ R10 notes. (22 ÷ ____ ) (*)

b. If a daisy has 21 petals, 168 petals will make ____ daisies. (168 ÷ ____ ) (*)

c. 72 pizza slices, each 1/8th of a whole pizza, will make ____ pizzas. (___________)

d. 230 mm will be the same length as _____ cm. (___________)

e. If a pool set has 16 balls, 192 balls will make ____ pool sets. (___________)

**Fig 5. Visual example used to explain the process of division**

**Fig 6. Exercise given to practice basic division**
With every exercise I would always start by showing the students which computation to use (*) in order to reinforce what we had established at the beginning of the lesson. This is in line with Vygotsky's concept of instructor-aided first attempts at solving problems until the student is confident that he or she can do it on his or her own. It is also supported by the theory of cognitive apprenticeship as formulated by Collins, Brown and Holum (1991). By using pictorial aids and speaking of ‘gathering’ units and ‘exploding’ units, I attempted to make ‘thinking visible’, to use Collins, et al’s terminology. I was ‘coaching’ (Collins et al, 1991) my students in their efforts at understanding the underlying principles, then showing them how to apply these principles by guiding them through several examples. Following that, they were given exercises with initial clues, and I monitored them as they
applied these themselves. Then I stepped back to allow them to proceed on their own.

‘HOW DO I MULTIPLY AND DIVIDE USING DECIMAL FRACTIONS?’

The two issues the students battled with were: (a) when should the comma move to the left and when to the right, and (b) by how many places? There was no time to revisit Grade 4 and 5 work. Consequently, I used the following very practical mnemonic: most people are right-handed and find it difficult to work with their left hands. Dividing produces a smaller result, and it is in human nature always to want more, not less. Therefore, dividing goes with moving the decimal comma to the left (our ‘clumsy’ side), and multiplying means the comma needs to move to the right – our ‘good’ side. Furthermore, the comma needs to move as many places as there are zeros in the numbers multiplied or divided. (Using the mnemonic described above may seem somewhat insensitive towards left-handed people, as, in the past, they have been made to feel that there was something wrong with them. However, one must also consider the relationship that develops between lecturer and students and the supportive atmosphere nurtured in the environment of a studio.)

Again, the initial exercises followed a strict pattern. That is, the students had to (in this order):

- Convert only bigger units into smaller units (multiplying) and use only whole numbers
- Then do the same, but with decimal fractions
- Then convert smaller units into larger ones (dividing) and use only whole numbers
- Finally, repeat this exercise, using decimal fractions.

This allowed the students to internalise solid patterns of computation and gave them confidence in this second zone of expertise. The goal was for students to achieve an almost ‘automated’ response to their engagement
with dividing and multiplying decimal fractions. Vockell (2001: Ch. 7) calls this ‘overlearning’, i.e. when a student becomes so familiar with a certain body of knowledge and skills, these become second nature to him or her. In this way the working memory is set free to engage with new challenges without having to expend time and energy on dredging up fundamental information and reconstructing methods needed for standard calculations.

The next exercise was one of mixed examples (dividing or multiplying), which forced them to choose the applicable steps themselves. Once the students felt comfortable with this step, I proceeded with an exercise of the same computations, but omitting one measuring unit (e.g., mm into m). In keeping with my pedagogic belief that it is critical always to try to make information as visual as possible, I included the diagram in Figure 9 in my notes to the students.

![Fig. 9: Visual representation of metric conversions](image)

### Exercise 3.3:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. 12,75 m =</td>
<td>= mm</td>
</tr>
<tr>
<td>b. 4,5 km =</td>
<td>= cm</td>
</tr>
<tr>
<td>c. 78600 mm =</td>
<td>= m</td>
</tr>
<tr>
<td>d. 21350,25 cm =</td>
<td>= km</td>
</tr>
<tr>
<td>e. 0,00003 km =</td>
<td>= cm</td>
</tr>
</tbody>
</table>

[Calculations: (a) x? ÷? (b) by how many zeros?]

![Fig. 10: Exercise to practise metric conversion, skipping units.](image)
Figure 10 shows how I guided the students by asking them to think in steps: (a) divide OR multiply? (b) by how many zeros?

Furthermore, Figure 11 is an example of the little informal tests I included at regular intervals and before a new skill or body of data was added. The students marked these themselves, and the total was always out of ten so that they could chart their own success. At the same time I also always included something slightly ‘foreign’, a little ‘speed-bump’, as in examples (e) to (h) in Figure 11. The purpose was to introduce, almost surreptitiously, examples which would force them to ‘realign’ learned knowledge and apply it to an unfamiliar challenge.

The ‘mini-tests’ mentioned above were included to build up a sense of achievement and comfort in the students in order to reduce, and hopefully finally banish altogether, their fear of numbers. It would also sow the seed of motivation in them which would lead to a genuine commitment to self-improvement through self-monitoring and self-study.

**Zone (c): more Data/concepts added (as per Figure 4):**

Areas of common shapes (triangles, quadrilaterals and circles) were addressed next. The students admitted that, besides having always been provided with the formulae during exams, they had also never been told
how the formulae for these calculations had been arrived at. In other words, they had never internalised this knowledge and had always relied on mimicry. It was my first task then to take apart the formulae and explain why and how they worked.

Once we had worked through examples of the basic shapes, we progressed to composite shapes, such as that in Figure 12.

![Composite Shape Diagram]

**Fig. 12: Advanced composite shape for the purpose of calculating area**

In Figure 12, students were challenged to do the following:

- Take apart the shape into a semi-circle, two rectangles and a triangle (in other words: analyse an unfamiliar image into known shapes)

- Establish the lengths of certain lines by comparing them to the given lengths of other lines (in other words: transpose and compare given data)

- Call to mind the formulae for the areas of the various shapes
• Be conscious of the fact that the formula for the semi-circle is that of the circle divided by 2

• Then synthesise by adding up the areas of the various shapes.

**Zone (d): contextualised problems (as per Figure 4):**

It was time to contextualise the conceptual knowledge which the students had gained by deploying these concepts in the various areas of design.

In Figure 13, the challenge was to convert the given measurements into metres first, and then calculate the surface to be covered with wallpaper in square metres. Of course, one could also calculate the area to be covered in mm² first and then convert the answer into m². The students and I briefly discussed the pros and cons of both methods.

![Figure 13: Contextualised example of calculating an area](image)

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100
2.2.3 Internal Differentiation in my Class

Now that the stages of my application of Vygotsky’s zones of proximal development have been demonstrated, I need to explain how I employed internal differentiation in my class.

I divided the class into three groups: those who had achieved 0–10 out of 30, those who had achieved 11–17 out of 30, and those with 19+ out of 30.

The rationale behind this grouping was two-fold. First, according to the concept of the zones of proximal development, it was important to establish the most basic mathematical skills (Zone (a) in Figure 4) first, before moving on to Zone (b). The second consideration was a more person-orientated one: I wanted to work, first of all, with only those students who had barely managed to answer one-third of the paper correctly because we could work at a pace with which they were comfortable; they did not need to feel intimidated by others who might call out the correct answers faster than they could calculate them; and we would not bore students who had had no problem with this part of the work.

Once the group (0–10 out of 30) had developed a firm grasp of the basic competencies, enumerated on page 7 of this paper, and had moved through Zones (a) and (b) of Figure 4, I added the next group (11–17 out of 30) and developed slightly more advanced examples, thus moving into Zone (c) of Figure 4. However, I made sure not to include anything too challenging; the object always was to lay down solid patterns of methodology and allow the students to develop a sound understanding of fundamental content knowledge. At regular intervals I asked the students to study their work critically in order to establish where and why they had stumbled. By asking them to do this, I hoped to establish a pattern of metacomprehension (Vockell, 2001 Ch. 7), that is, that students would become aware of their own progress in understanding vital concepts. According to their insights and requests, I devised more repair strategies where necessary.

This approach had mixed results. Some students asked for more exercises, even if it was just another sheet of the same exercises to take home and practise again. Some sat in pairs or groups and worked with each other.
One young man told me that he had worked out exactly which step during metric conversions he had not understood before, and that once he had eliminated that obstacle, he was coping well. The students started making adjustments to their learning process and monitored their progress without further input from me. The two students’ responses below reflect that our collective efforts were bearing fruit:

I learned to identify problem areas in certain subjects I’m taking, e.g. conversion in Maths. I also learned to find a solution to these problems.

I am able to understand problems, situations, effects and experiences much better. For example, why I did not do too well at school in Maths.

Once the first and second groups seemed to have internalised the necessary fundamental knowledge and skills adequately enough (time constraints, unfortunately, played a major role), they were given worksheets with relatively easy contextualised tasks (mainly calculating area and volume of basic regular prisms). Figure 14 is a typical example (perhaps appealing to industrial or surface design students) taken from such a worksheet.

![Fig. 14: A typical example from a numeracy worksheet involving the calculation of area](image-url)
After two such worksheets, the last group joined in, and we briefly revised the areas of more advanced shapes (trapezia and composite shapes). This was followed by another set of exercises which pertained to such more complex shapes.

The next hurdle to attempt was teaching the students the features of regular prisms, how to calculate their total surface area and volume, and then how to do the same with composite prisms.

Figure 15 is an example of an easy prism, the only challenge being that the students had to work with the area and circumference of a semi-circle. (This example would appeal to Graphic Design students as they might be asked one day to design wrappers for food items.)

![Photo: M. Rohlwink](image)

**Fig. 15: Calculating the total surface area and volume of a regular prism**

Again the students were given a worksheet with similar examples of typical calculations they would have to do in their various design disciplines.

As they became more comfortable with such calculations, I added new aspects to the problems, always working outwards (as per Figure 4) towards Zone (e), stretching their newly established knowledge and acquired skills and reminding them of the profession in which they would one day apply these skills.
Figure 16 is one such contextualised example of a typical, but very basic, quotation which an Interior Designer might have to submit one day in the workplace.

2.1. A concrete slab (100mm thick) has to be laid down as foundation for the room. Using the above measurements, calculate the volume of concrete needed for the foundation in m³.

2.2. Per asks you to source good quality porcelain tiles for the entire floor.

2.2.1. The tiles you suggest are 600mm x 600mm large. How many tiles, to the next whole tile, do you need?

2.2.2. Add 15% wastage to the number of tiles needed. (Always round up to next whole tile.)

2.2.3. If the tiles come in boxes (4 tiles per box), how many boxes do you need to buy? (to next whole box)

2.2.4. At a price of R 192.00 per box, how much will the tiles cost?

Fig. 16: Calculating area, volume and percentages
Finally, the students were given a summative assessment task in order to establish their progress. Fig. 17 is an example taken from the June examination paper.

![Diagram of candle arrangement](image)

**Fig. 17: A question taken from the June examination**

3. **The Results and Analysis:**

Table 3 indicates that metric conversions, basic area and volume calculations, as well as the total surface area of a prism, are still problematic. However, Question 4, which dealt with the volume of regular prisms, was answered fairly well, as was costing, which had been woven into the remedial tutorials at regular intervals. The average for the class had improved by 10% and was now a pass mark.

<table>
<thead>
<tr>
<th>Percentage Range</th>
<th>Students</th>
</tr>
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<tbody>
<tr>
<td>0 – 33%</td>
<td>13</td>
</tr>
<tr>
<td>34 – 59%</td>
<td>27</td>
</tr>
<tr>
<td>60 – 100%</td>
<td>15</td>
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</table>

**Table 4: Further breakdown of the marks**

The table shows that there was a marked shift in results. Almost twice as many students passed with 50%+%. The number of students who could not
answer more than a third of the questions correctly had halved, and the number of students who obtained 60+% had increased substantially.

Unfortunately, there were also students who progressed only minimally or not at all. An intellectual understanding of metacognition, brain capacity and self-regulation, of course, does not necessarily translate immediately into changed behaviour (commitment, attitude and attention – the most important metacognitive skills) and subsequent success. One student had written in her reflections on what I had taught them about our memory and on metacognition that she found it: ‘... pretty boring; never had to learn about it; pointless’.

Her marks dropped from 30% for the diagnostic test to 20% for the June paper. Other students who still struggled admitted that it was mainly a lack of confidence. Some felt that, as long as I was there to correct them if they made mistakes, and as long as there was no time limit set for the tasks, they felt safe. However, as soon as they were asked to work independently and needed to complete the work within a certain timeframe (which was a very lenient one), they grew apprehensive and started doubting their own abilities. Nevertheless, they were all (except one) eager and committed to continue working with me on further tutorials.

**CONCLUSION**

The above programme of testing, an introduction to metacognitive skills, remedial tutoring and re-testing has been a loosely assembled one with interspersed reflections and feedback from the students. It was a first attempt at providing students with a particular type of support in order to better facilitate epistemological access. The results of the June examination and the comments made by students who are self-driven indicate that my approach has borne fruit.

I have decided to develop a far more structured programme for the next intake of students. They will also be asked to keep a regular learning journal to record their progress, as well as their thoughts and reactions to the work done in the Numeracy component of Professional Business Practice. Such
reflective learning would allow them to witness the unfolding of their own cognitive skills and self-regulation so that they could become active agents in their own intellectual development (Vockell, 2001: Ch.7) and become proficient in the required mathematical skills.

Ideally, I should be able to block off at least four weeks at the beginning of the year to teach about metacognition and self-regulated learning, as well as the different types and levels of thinking. This should give the students the courage to ‘follow’ me as I offer them epistemological access into the realm of basic Mathematics. Unfortunately, in the first term of this course they have to familiarise themselves with so much else of immediate importance that I have to introduce them to their own limitless brain and cognitive abilities, and the world of basic mathematics, in increments throughout the year.

Furthermore, the following comment by a student, “When I walked out of Matric I thought that I had closed the door on Mathematics forever. And now, in this Design course, you want me to do Maths again?!” reflects the reaction of a fair number of students to the Numeracy component of my subject. It is only as the year unfolds that the students come to realise that basic mathematical computations are very much part of their projects.

I, therefore, see my most serious challenge as two-fold: (a) breaking down the resistance to the Numeracy component of my subject as early as possible, and opening up the students’ minds to their own intellectual capacities, and (b) aligning the work that needs to be done in the Numeracy component with the work that is done in the practical modules in order to demonstrate to the students the importance of mathematical skills.

It is an Extended Curriculum Program, and I trust that as long as the students have learned how to learn; have thought about their thinking patterns; have developed self-confidence; and are motivated to explore the world of design knowledge that they have chosen, then constructive learning has happened and serious progress towards success has been begun.
List of images

Per Mertesacker. Wikipedia (Creative Commons).

REFERENCES


ENHANCING STUDENT LEARNING IN A FIRST YEAR ACCOUNTING MODULE AT THE UNIVERSITY OF THE WESTERN CAPE VIA THE USE OF ‘CLICKING’

Ronald Arendse and Judith Jürgens

ABSTRACT

Increasingly, universities place emphasis on effective teaching and learning and, with decades of research available, modern module design should also entail teaching that is informed by such research. One tenet of teaching that emerges from research is that students need to be actively involved in the learning process (Gregory and Jones, 2008). Learner-centred teaching practices encourage the use of innovative initiatives, particularly in the realm of technologically assisted teaching. One such innovation is the use of the interactive learning system (ILS) – also known as ‘clickers’ – to ensure a regular interaction between lecturer and students with immediate response possibilities. The use of interactive questions for the ILS clickers in combination with slides in lectures can reflect the understanding of the class at a specific point in the lecture and indicate student learning. The students’ responses could potentially change the direction of the lecture and/or evoke discussion.

The ILS also creates an opportunity for the reinforcement of concepts, experiments, calculations, etc. Research so far has indicated that clickers can be very effective for testing individual learning within large classes and encouraging peer learning and debate (Lyman, 1981; Mazur, 1997). Furthermore, according to Beatty (2004), students feel that ongoing and immediate feedback on their understanding is beneficial and the ILS
promotes rapid feedback from the lecturer who can then redirect the students’ learning within the lecture.

The University of the Western Cape (UWC) has put the ILS to the test with an Accounting Foundation module (Accounting: 160 students) offered in the Economic and Management Sciences Faculty (EMS). This paper will look critically at the use of clickers to enhance student understanding and reinforcement of taught concepts as well as outline the challenges of using this tool in the classroom at this institution. It forms the first part of a reiterative, reflective cycle of teaching and learning evaluation for innovative practices at first-year level.

**Key words:** clickers, feedback, peer instruction, scaffolding, student engagement.

**INTRODUCTION**

Technology plays an ever increasing role in our daily routines, from checking e-mails to working on computers and using our mobile devices to do more than simply make a call. In an increasingly globalised view of education, there is a drive in universities to increase the use of technology in teaching and learning to mirror the demands and expectations of the working world. In spite of some acknowledgement of this, Higher Education in South Africa has been slow to use and make available the huge variety of suitable technologies in the classroom or as learning spaces required to meet the needs of the student body. Students of the digital age require information immediately and the widest access to new knowledge comes via the multiple technologies that universities expect students to utilise as a norm (Draper and Brown, 2004; Corlett et al, 2005; Shank, 2008). The World Wide Web (www) provides students with an array of information readily available and accessible from anywhere and at any time. This is a feature of global interaction and one that should be brought into teaching and learning, ensuring that students have the resources and information available to them. This strongly suggests a move towards a blended learning and

One focus of this paper is on student learning and teaching choices, based on research findings over at least the last two decades. In these, teaching is no longer seen as only a means of disseminating knowledge, but also of modelling, facilitating and demonstrating, and encouraging students to construct some of that knowledge through their own experience, in order to critically evaluate current knowledge and to develop collaborative strategies for doing so (Khaddage et al, 2009; Beatty, 2006; Draper and Brown, 2004; Mazur 1997). This means that learning entails not only the process of construction and practice, but also reflection and revisiting conceptual knowledge to reach deeper levels of learning (Ramsden, 2003; Scott, 2009; Butcher et al, 2006).

To ensure that the lecturers fulfil their function in the teaching and learning process, i.e. to see if there is transfer of knowledge and skills, ‘measuring’ (qualitatively) student engagement is clearly important. Ramsden (2003) provides six principles as guidelines for effective teaching, student engagement being one of them. He proposes that lecturers should get students engaged to enable them to reach understanding for the realisation of deeper learning. This would be the cognitive approach to developing a higher-order, thinking skills curriculum (Ramsden, 2003). The cognitive approach aligns itself with the concept of ‘scaffolding’. The notion of scaffolding encompasses a process in which students are given support until they can apply new skills and strategies independently (Rosenshine and Meister, 1992). Scaffolding can therefore take place in individual instances where lecturers are able to identify misconceptions students might have. The forms that scaffolding takes can vary depending on the desired outcome, the current level of student understanding and the nature of the learning required. It is with these variables in mind that the use of clickers is proposed as a tool to support student engagement and, therefore, learning.
The ‘clickers’ are wireless, handheld devices as small as a cellular phone from which responses are sent to a centralised system. These responses are selected by students and are ostensibly anonymous (although it is possible to identify which student has which numbered device). The devices facilitate engaging the entire class because each device is numbered and responses are made visible below the questions, so that the numbers of responders, but not their identities, are immediately visible. The system then tallies the rapid responses, and this information can be displayed to the class in graphic form showing the proportion of chosen answers. This easily lends itself to initiating a discussion while simultaneously giving the instructor/lecturer a quick overview of the class understanding of crucial concepts.

The responses are displayed in the form of bar graphs representing the percentage of votes allocated to each option. This gives the lecturer the opportunity to immediately probe the students about the choices which they selected and have them discuss the answers. This, in turn, demands peer interaction and the necessity of elaborating answers, which can stimulate and show student understanding and interpretation of a specific question. We will return to this issue of peer interaction below when discussing the benefits of using clickers in the UWC context.

Mazur (1997) is one academic teacher and researcher who promotes the use of clickers to get students to engage with their peers, thus encouraging active learning. Mazur’s reason for introducing this system was to test at what level his students were thinking; he found this to be at the lower level of memorisation and not at the more complex level of understanding and application. He wanted students to tackle certain problems using their peers for support, thus engaging them at a higher cognitive level where they were required to express their thoughts and elaborate to their peers their understanding of the content. He documents the process as follows:

a. The lecturer poses a complex, multiple-choice question to the class.

b. The students then answer the question, using the clickers.
c. The lecturer shows the student responses to the class.

d. The lecturer asks the class to discuss and share their answer with their peers and why they selected that answer.

e. The lecturer then asks the students to ‘vote’ again for what they now perceive to be the correct answer.

f. The lecturer discusses the answers with the students and displays their new responses. (Mazur, 1997)

This process, which centres on peer intervention and is known as the ‘Mazur sequence’, has provided one approach to large-class teaching. Emphasis is laid on the principle of using peer instruction to involve students in the learning process within lectures. The necessary conversation between students demands giving a viewpoint and reasoning, and the communicative function is persuasion or clarification and agreement. Such interactions, if focused on content matters, are engaging students in higher order thinking and are thus likely to result in real learning (Boud and Falchikov, 2007).

Another principle, which Ramsden (2003) emphasises, is that of lecturers learning from students, where lecturers gain vital feedback from student participation. Lecturers need to understand that, although participation alone should not be rewarded, student participation and engagement are important mechanisms for the lecturer because feedback should be a two-way process (Campbell and Norton, 2007). The lecturer provides feedback to the students on their progress thus far and gives the students insight into what is expected, what problematic areas there are and how to tackle these. This feedback may take the form of general feedback in a lecture theatre, a written comment on a script, or a spoken comment in a one-on-one consultation session. The feedback from the students provides the lecturer with greater insight into the students’ thinking and their manners of learning or processing information. This feedback to the lecturer comes in the form of questions in class, class discussion and students’ performances.
on assessments. Having students engage with the content in class and be active learners shows the lecturer whether learning is occurring. This principle of two-way feedback is facilitated by the use of clickers.

There are additional claimed benefits to using this technology, such as the increasing and maintaining of student attention and participation, the potential to adapt the lecture based on immediate student responses and the encouragement of peer learning.

When classes are large, it is not easy for lecturers to ensure that all students are actively discussing and sharing their thoughts on material. Likewise, having students ask questions in a large class can be intimidating for students and thus counterproductive for lecturers wanting to establish learner understanding. All too often, the question is asked, ‘Do you all understand?’ and silence is considered assent, so the lecturer moves on. The use of clickers can prevent this misrepresentation of student levels of understanding by giving students the option of answering anonymously and thus ‘safely’, so that they feel able to test their own learning as part of a supportive learning environment.

In the more traditionally taught large classes, any discussions are usually dominated by a small confident group of learners who interact, ask questions and debate with the lecturer. What the use of clickers encourages is the airing of different opinions of a greater number of students who begin to feel more comfortable in class discussion, not only because the public responses to questions are anonymous but also because the student is unlikely to be the only one with misconceptions or queries about any specific concept. This enables students to move away from thoughts such as ‘I am the only one who’s lost’ or ‘I am the only one who doesn’t know the answer’ and assists in the removal of fear of public humiliation if the answer is not correct.

At UWC, this insecurity is common among students, particularly in their first year, since many are cognisant – or are made acutely aware by lecturers – of their inadequate schooling background or lack of cultural capital. For
students who are afraid to speak in front of the class, opportunities now arise to speak only to a neighbouring classmate, which is so much less daunting. Responding via a clicker can thus build student confidence as well as keep the students’ attention for the full duration of the lecture since they are periodically called upon to respond.

With the responses of the students graphically/visually represented, students’ understandings of specific concepts are made visible to the whole class (without individuals being identified), thus allowing revision to take place or certain concepts to be reinforced. The learning process is therefore enhanced, which brings about better teaching. This claim depends on how the tool – and the students’ answers – are used. As William Wood (2004) makes clear: ‘Like any technology, [clickers] are intrinsically neither good nor bad; they can be used skillfully or clumsily, creatively or destructively. However, they can produce results that are eye-opening and potentially of great value to both students and instructors for enhancing the teaching-learning process.’

THE CONTEXT OF THE STUDY

The faculty of Economic and Management Sciences at the University of the Western Cape (UWC) has introduced an extended degree programme as part of the Bachelor of Commerce degree. The aim of the Extended Curriculum Programme (ECP) (which takes a year longer than the standard degree programme to complete) is to broaden access to universities in South Africa to fulfil one of the core goals of the National Academic Plan for Higher Education (NPHE, 2001). Providing these students with the opportunity for access with the likelihood of success calls for new and innovative ways of teaching: formal access alone is insufficient; universities also need to enable epistemological access for success to be achieved. Increasing numbers result in larger classes, which may be counterproductive to this aimed-for success, and so additional strategies need to be undertaken to enable it (Scott, 2009). Using technological innovation is one way of doing so.
Because of very diverse large classes at UWC, many ECP lecturers have adopted the traditional approach to teaching, which has the lecturer as the centre and source of all information, the ‘gatekeeper’ of all knowledge (Ramsden, 2003). In practice, this approach sees students as ‘consumers’ of information, with limited interaction between the lecturer and students or among students themselves (Biggs, 1999). Furthermore, the primary mode of lecturing used is the transmission mode, in which Bales (1996) estimates that only 5% of the information is retained by students. Introducing the use of clickers in the classroom was an intervention intended to counteract this attitude to student learning.

**DESIGN OF THE STUDY**

Believing that the competent use of technology should be embedded in classwork as a norm, this study aimed to examine if one technological device – clickers – would be effective as a tool to increase the level of student engagement with the lecturer as well as amongst peers within a large class environment. Two first-year Accounting classes, with 160 students in each, were selected as the groups to test the level of student engagement through the use of clickers. The level of student engagement had become a cause for concern for the lecturer as the same few students always participated actively while the rest were silent, their levels of understanding unknown.

For the purposes of this study, the topic presented for both classes concerned ‘bank reconciliation’, with a set of three lectures spent on the topic. The lectures were designed in line with specific lecture outcomes, which included students being able to analyse bank statements, to find reasons why balances in the bank statements and bank accounts in the general ledger differed, to record outstanding entries, to complete the relevant cash journals and to prepare a bank reconciliation statement.

Three to five multiple-choice questions based on the topic were prepared for each lecture to encourage class engagement in discussion. The lecturer
had the option of posing these questions at any point during the lecture. The students made use of clickers to make known their choice of answer.

For example, in the second lecture students were asked to do a brief recapitulation of what they had learned. One of the questions posed to the students was:

If the bank statement has a credit balance the account would be classified as:

a) Income to the business
b) An expense to the business
c) A liability to the business
d) An asset to the business.

Figure 1 shows the students' first attempt at answering the question with the correct answer being 'D'.
Although it is clear that half the class got the right answer, the lecturer needed to correct the gross misperception of what a ‘liability’ meant. Rather than simply tell the students that they needed to remember this word and its implications, he asked the class to enter into a discussion where they would have to convince their peer of the correctness of their own answer with the minimal guidance of the lecturer. The discussion took approximately five minutes before the question was posed once more. The second response saw 98% of the class now selecting the correct answer. On questioning by the lecturer, the primary reason given for the misconception was that most students were not familiar with bank statements, not having bank accounts themselves, so they could not relate to the question or make sense of what was being asked. The terms thus meant little because of this unfamiliarity with banking systems.

IMPLEMENTATION AND IMPLICATIONS

Throughout the lectures, various questions were posed to the students of both classes following the Mazur sequence. Once the students in the class had made their selections and voted anonymously, the results were almost instantly displayed graphically for all students to see. The class were then instructed to discuss their chosen answers with their immediate neighbours before being asked to vote once more using the clickers. Again the responses were displayed, so that a shift of more students gravitating to the correct answer became immediately visible to the students themselves. This is an important point since it differs from the usual assumption or rough assessment by the lecturer on student progress. Depending on the number who now answered correctly, some guiding questions could be posed by the lecturer and students asked to discuss the problem with their neighbour on the other side before again voting for an answer. Most commonly, it was found that a sharp increase of correct answers took place. The lecturer would end the question session by explaining and clarifying certain concepts, based on the nature of the answers.

The peer instruction was effective in both classes and had a great influence on student engagement and student participation. This could have been possible without the technology, but it was an effective mechanism for the students in promoting discussion and a friendly competitiveness in relation to the topic under study. Hence the pedagogical approach to teaching of using clickers as a teaching tool had increased student learning and participation.
When we select a tool we need to understand the context of the task and the class, which is why a detailed analysis of the class was provided earlier. The tool used depends on not only the aimed-for outcomes of the specific task but also the specific needs in a given context before we can determine whether it is useful or not. An important consideration in a South African context, and even more so for UWC as one of the most financially hamstrung of the universities, is cost. The clickers are an expensive tool, but do they add value?

**ADVANTAGES OF USING CLICKERS**

Using the clickers had several advantages, outlined below. An important point to be made about the particular UWC context is that in spite of the high cost of the clickers in South Africa, students are ‘tickled’ by them, and since the majority of students’ technological experience is limited by the same resource issue – not enough money – clickers have achieved several positive results. Being able to use clickers has served as an introduction to more sophisticated technologies, breaking down feelings of inadequacy and fear of technology. Using clickers has also nurtured cross-cultural collaboration as students have come to see how competent their peers are. Thus cultural preconceptions are broken down too.

Another advantage relates to the identification of problem areas. As answers are displayed visually for both students and lecturer to see, discussion is easily facilitated. In addition, when the results were displayed the student responses were automatically saved. When the lecturer posed the question for a second time, the students’ responses could be compared to the first submission of responses, which provided a tool for the lecturer to do a quick analysis and comparison. These additional features constituted feedback for the lecturer to engage with after class, and to determine where certain misconceptions lay.

One of the more important aspects of using clickers is that student responses remain anonymous, a key factor in creating a ‘safe’ environment for responses and one which increases the participation of all the students (Trees and Jackson, 2007). Student levels of anxiety at being asked questions in class mostly centre on social exposure and fear of looking ‘stupid’. The clickers remove this apprehension.
In respect of engagement, we can use Anderson’s model (2008) of six types of educational interaction: student–student; student–teacher; student–content; teacher–teacher; teacher–content; and content–content engagement. The level of engagement which was missing from the class before peer instruction was that of student–student engagement. The level of student interaction increased by creating high-order-thinking questions and having students discuss their answers with their peers. Teacher–student engagement occurred throughout the lecture but particularly at critical points where the lecturer provided clarity and expanded on certain concepts. Prior to the in-class activity, the lecturer engaged with the content to develop those critical questions which were designed to create class discussion and have students move towards a deep learning approach. Once more, the interaction in class between student–and–content and lecturer–and–content continued as the students actively engaged with the questions and provided feedback in terms of responses, questions and discussion.

As a critical part of the reflective cycle, it became crucial for the lecturer to note at this point what the data was to be used for and whether it could assist him to look again at the content previously taught. For example, the lecturer aimed to revisit the manner in which students answered the questions and consider whether or not the misconceptions could have been prevented if certain concepts had been reinforced in some other way: e.g. if we refer back to the bank reconciliation question where the misunderstanding was due to the lack of prior knowledge and poor vocabulary, the misconception could have been avoided if the generality of bank account knowledge had not been assumed by the lecturer.

**CHALLENGES OF USING CLICKERS**

Although this particular class of students demonstrated that the use of clickers was an effective tool, various challenges have been encountered since the establishment of the research project. The major ones include technical issues; developing a facility for good multiple choice questions; managing the time required to set up, implement and fully utilise the potential of the system; and managing large group discussions in new ways, given the exigencies of logistical problems at UWC. Examples of technical challenges are that, as with any new technology, the staff members and students need time to familiarise themselves with the system, and also alternatives must be available if, for some reason, the central computer is
not receiving the signals from the clickers. The development of suitable, group-specific multiple-choice questions that will encourage discussion requires considerable expertise; simple or obvious answers will not give rise to discussion between peers so the answer choices need to be authentically taxing and debatable. One of the most important aspects of using the clickers to teach involves being better able to understand what constitutes ‘good’ and ‘bad’ interactive questions. These challenges are, however, not all specific to the tool being used. There are some challenges when working with clickers but we need to use technology as a lever to change the teaching, not just do the same thing differently.

Furthermore, lecturers need to spend considerable time preparing for such interactive sessions so that monotony does not become a problem, and student responses in such sessions need analysis, reflection and adaptability. This is particularly true because the basis of student error or misconception is not necessarily obvious and may require class time to probe without disrupting the anonymous nature of the process. Occasionally, no matter how well planned a lesson is, the lecturer must be able to spontaneously adapt the approach and pacing to provide the full benefit of using the system to student advantage. Finally, the peer discussions must be carefully managed so that optimal learning takes place. This again refers back to careful preparation so that follow-up questions and activities can ensure full involvement of all students in the issues under discussion.

These points speak to the three main issues of interest in this research study: increasing the level of student engagement within large classes; looking at the appropriate selection of tools to assist with teaching large classes; and deciding whether or not technology can assist in student engagement in large classes.

**CONCLUSION**

Clickers are not to be perceived as a novelty to be used as a way of doing assessments so that the lecturer can avoid grading papers, or as a tool to assist with improving attendance by forcing students to respond via clickers as a means of taking a roll call – the value of the tool extends far beyond that. Clickers can be used to assist in debates and discussion questions so that there is no need to set a question with one correct answer. Clickers can be a powerful tool if integrated and implemented correctly, providing benefits in large-class teaching. At UWC, the novelty of the devices has
created excitement in the class, and they actively engage students so that their participation has become a central part of the learning process.

The impact clickers have had on student responses is also a result of the rapid feedback accessible to the lecturer to assist in providing an accurate analysis of students’ responses. An important aspect of using technology in the class is that it keeps the students active and interested and maintains their attention.

REFERENCES


National Plan for Higher Education (2001)


TEACHING AND LEARNING STRATEGIES AIMED AT FACILITATING EPistemOLOGICAL ACCESS TO THE BACHELOR OF SOCIAL WORK DEGREE

Shemaaz Carelse

INTRODUCTION

In keeping with its concern for under-prepared students gaining access to disciplinary knowledge, the University of the Western Cape (UWC), a historically disadvantaged institution, currently runs an Extended Curriculum Programmes (ECP) across many of its academic programmes. The Social Work Department has offered the ECP in the Bachelor of Social Work degree (BSW) since 2010. The ECP consists of four social work theory modules of which students take two per year during their first two years of study. These modules have been successful in yielding epistemological access to under-prepared students, and it is on these modules that this paper focuses. Thus the goal of the study and the focus of this paper are to describe the teaching and learning strategies and techniques employed by the ECP lecturer who facilitated epistemological access in the BSW.

THE CONTEXT

The class consists of 40 students who are diverse in terms of ethnicity, language, gender, culture, religion and academic ability. They are predominately students who matriculated between 2008 and 2010 and who scored between 23 and 26 points in their Matric\(^2\), or applicants who gained

\(^2\) For admission to degree and diploma programmes UWC use a weighting system for calculating points i.e.:
access through Recognition of Prior Learning (RPL) who have not completed Grade 12 or who have not obtained an endorsed National Senior Certificate (NSC). A smaller proportion of the class are students who completed the Department of Education and Training (DET) Matric prior to 2008, but who did not pass with Matric exemption and are more than 23 years old. These criteria are all in line with the UWC alternative access policy.

CONSIDERING PAST LEARNING EXPERIENCES

Student learning is linked to individual student potential and the particular way in which an individual learns (Ramsden, 2003). For instance, UWC continues to draw students from low socio-economic groups and poor schooling backgrounds due to its admission policy which explicitly targets previously marginalised groups. Studies show that students from disadvantaged schooling backgrounds struggle to adapt to Higher Education (HE) demands and, therefore, the failure and dropout rates remain high for this cohort (Scott et al, 2007; Breier, 2010). ECP students thus enter Higher Education with a particular academic disadvantage as their schooling has undermined critical thinking practices and has not promoted a culture of learning and reading for academic development. However,

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<th>National Senior Certificate Levels</th>
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For admission to the Social Work ECP an applicant must have an NSC Level 4 for English; Level 4 for Life Orientation; Level 3 for any other additional language; and Level 3 for Mathematics. These in addition to their other subjects must make up between 23 and 26 UWC points.
student assessments of the ECP indicate that the majority of these students did manage to develop critical thinking and discipline-specific knowledge while engaging in the four ECP theory modules. This enabled their understanding and ability to construct knowledge about the related concepts in the BSW (Social Work Department Extended Curriculum Quality Assurance Report, 2010–2011).

The development of learners’ understanding requires them to be actively involved in the process of meaning making (Johnson et al, 2007). Furthermore, a learning environment needs to be created where adult learners can create and reflect on their own experiences and (social work) practices in an engaging way together with lecturers (Bozalek, 2009). Additionally, learners should be at liberty to question assumptions of knowledge and to critically reflect on such knowledge. It is when learners engage with each other and their teachers about knowledge, skills and attitudes that meaningful learning occurs (Biggs, 2003).

**SOCIAL CONSTRUCTIVIST TEACHING AND LEARNING STRATEGIES AS CONTEXT FOR EPISTEMOLOGICAL ACCESS TO THE BSW**

Constructivist learning approaches that enhance the possibilities for epistemological access include methods such as active learning and discovery learning. It is when students engage in such ways of meaning making combined with appropriate pedagogy that knowledge construction can occur. In this regard, the lecturer as expert is not dismissed but his/her role is modified to become ‘the facilitator of learning’, while the student constructs knowledge by engaging with others in problem solving (Driver et al, 1994). Brooks and Brooks (in Tam, 2000) concur that the lecturer as facilitator encourages and accepts that the student can learn independently and take initiative. In this context the lecturer creates and maintains a collaborative, problem-solving learning environment for students to construct their own knowledge while the lecturer acts as guide (Tam, 2000). This relates to active learning which is synonymous with constructivist learning in that, among other things, learning is facilitated by engaging the adult learner in dialogue (Vella, 1994). Hence learning happens through interaction between the learner and a more knowledgeable other who leads the learner from the known towards generating new knowledge and experiences. This links to the Vygotskian theory of zone of proximal development (ZPD). This theory (Vygotsky, 1967) relates to the distance between the learner’s actual developmental level (what the learner can
achieve when engaging in problem solving independently) and his/her potential developmental level (what the learner can achieve through problem solving with the help of capable others).

Thus to reach the ZPD a learning environment needs to be created where the learner can create and reflect on his/her own experiences (Bozalek, 2009); in other words learning from experience or experiential learning (Amstutz, 1999). However, for the process of learning to take place experience (input) alone is not sufficient but reflecting on one’s experiences (output) is required for learning to take place. This is in line with constructivist theory that learning (output) happens when people make sense of their experiences (input) and can apply new knowledge to real world experiences (Kolb, 1984, cited in Atherton, 2005). Kolb’s four-stage model of experiential learning, which is based on the work of Atherton (2005), and Moore and Van Rooyen (2002), suggests that the first stage is the learner’s lived experience (Concrete Experience); the second stage relates to making sense of the lived experience (Reflective Observation); the third stage involves transforming the experience, by forming ideas and making generalisations about the experience (Abstract Conceptualisation); and the fourth stage consists of transforming the ideas and generalisations by applying them in different contexts (Active Experimentation). Thus the process of learning can start at any one of the four stages as it is continuous. In other words the learner can go through the cycle many times during the learning process. The model lays emphasis on the context in which learning takes place (Ralphs and Buchler, 1998, as cited by Dykes, 2009).

**EPISTEMOLOGICAL ACCESS IN THE BSW**

In the ECP under review, strategies such as classroom discussions and eTeaching discussion forums, group presentations, debates, case studies, essay writing and concept mapping were all planned to facilitate students’ own construction of knowledge. The purpose of these activities was to have students internalise or ‘own’ new knowledge that could be applied in real world contexts when they engaged with clients in practice education later on in their studies. This approach relates to authentic learning which reflects alignment of content, learning outcomes and discipline-specific knowledge (Lombardi, 2007).

Hence to create opportunity for teamwork among such a diverse group of students, the lecturer placed students in small groups of five members to serve as ‘collaborative groups’ in the first semester. These groups were
assigned tasks, on a weekly basis, that were in preparation for, and facilitated during, lectures. As part of their preparation for lectures students were required to engage with certain tasks on their own, either individually or in groups. These involved students reading prescribed texts identified by the lecturer at the end of a previous lecture session. Students were further required to engage in discussions with group members to ‘unpack’ concepts that were unfamiliar to them. They could also make use of consultation with the lecturer as well as the tutor in this regard. For most lectures students were expected to do presentations of the summary of the reading assigned to the various groups. In this way they were assisted by the lecturer in dealing with experiences by interpreting learning challenges and making sense of new knowledge. Such an environment called for assessment that was open and transparent. Additionally students constructed new knowledge and learnt more about themselves in a ‘safe environment’. This strategy calls for an emphasis on students’ strengths and not their deficits (Green and von Schlicht, 2003). For example, one of the presentations facilitated by a group was a rap song on lecture content. Another example was a role play accompanied by a narrative and PowerPoint presentation to share knowledge pertaining to child abuse. A third example was the use of a talk show scenario to illustrate students’ understanding of social issues affecting Cape Town communities. In this way the students used media that were familiar or commonly used to share their constructed knowledge.

Formative assessments were scaffolded to facilitate effective/active learning. For example, the first assessment focused on group presentations in class on a particular topic pertaining to the module. The purpose of assessment was teamwork, communication skills, use of technology, research skills and presentation skills. This was followed by an individual essay on the same topic as the group presentations. The purpose of assessment for the essay was to assess students’ ability to access relevant information using various sources such as Internet, library etc.; furthermore they were assessed on their ability to summarise a text as well as their writing skills which included in-text referencing as well as producing a reference list according to Harvard style referencing. The third assessment was an individual assignment.

3 The lecturer would make assessment of students’ developmental needs and refer individuals or collaborative groups to the tutor who was a postgraduate linguistics student. Tutoring sessions focused on reading, writing, and study skills of the ECP students.
in which students constructed a concept map (C-Map) depicting the links between concepts used in the group presentation in class and the individual essay. For this task students were assessed on their ability to use an eTeaching tool, utilise research, summarise texts and display writing skills.

From the examples mentioned we can see that social constructivist teaching and learning strategies were constructed in such a way that students were required to work independently as well as collaboratively. This meant that when students engaged in group work tasks each individual had a specific role and responsibility. The assessment criteria were specific in terms of self-reflection and accountability towards the group (members). In addition to these, particular skills were targeted for the purpose of development and growth to meet the learning objectives. These included critical cross field outcomes such as use of technology (PowerPoint presentation and C-Map), working in a team and problem solving.

CONCLUSION

The challenge of gaining epistemological access to any degree programme stems from a particular student’s schooling background which promotes rote learning and negates a culture of critical thinking. It is apparent that the social constructivist strategies and techniques for student learning are best suited for the development of critical thinking and therefore academic discourse. Such teaching and learning strategies are aimed at the construction of meaning and aid students to apply new meaning (or knowledge) in the real world context, thus providing epistemological access to the BSW.

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PEER MARKING AS A PEDAGOGICAL TOOl FOR EPISTEMOLOGICAL ACCESS

James Garraway

Peer assessment has been extensively referred to in the higher education teaching literature across all fields of study (e.g., Gibbs, 1999; Yorke, 2001; Biggs, 2003; Nicol and Macfarlane-Dick, 2006). As it involves high levels of giving feedback, it is usually placed within the broad thrust of formative assessment in higher education. The case presented in this chapter argues that peer assessment can be a powerful tool for giving students access to the ways of thinking and doing in a mathematically-orientated, applied science subject, namely Mechanics. This is so because, as has been argued by Gibbs (1999: 46 and 47),

The act of marking brings with it a heightened focus of attention to detail and a new perspective on one’s own work which simply tackling the problem may not achieve . . . [it] concerns the internalisation of criteria for quality.

DEFINING FORMATIVE ASSESSMENT

Formative assessment, of which peer assessment is an example, broadly refers to that sort of assessment designed to help students, through the provision of constructive feedback, to improve their work (Knight, 2001). The nature of giving feedback is essentially dialogic in that both givers and receivers are engaged in conversation rather than a one way transmission of information. In this way student learning is more likely to occur (Yorke, 2001; Nicol and Macfarlane-Dick, 2006). Formative assessment may be broken down into at least two distinct phases. There is firstly the recognition from the learner that there is some gap or difference in their learning which is
different to a desired outcome for a course. It is most frequently the role of
the teacher to identify the nature of this gap and to communicate it to
students; however, peers or even self assessment may also fill this role. The
second phase involves the student taking some form of action to close the
gap, in other words some sort of active engagement with the task at hand
and the nature of the feedback given (Black and Dylan, 1998).

The learning model for formative assessment is essentially that of
constructivism in which the student is provided with tools (feedback) on their
earlier understandings that then enables them to move to more complex or
even higher order understandings (Nicol and Mcfarlane-Dick, 2006; Biggs,
2003). Through working with feedback the externally developed
understandings can become internalised and then used by the individual
student to interpret new problems or even to produce their own texts within
that field.

In order for formative assessment, and hence peer assessment, to be
successful it should involve staff and students in examining and surfacing
disciplinary epistemologies (Yorke, 2001). In other words formative
assessment should focus on the underlying rules for understanding and
generating knowledge in that discipline or field. In doing peer assessment,
for example, students may take on the role of the expert marker who
‘knows’ what counts as valid knowledge and what stands outside of this.
Through practicing being the expert with their peers students can begin to
internalise the rules of the discipline and use these to guide their own
practices.

It should be acknowledged that not all peer assessment does this. Peer
assessment may only deal with the surface features of the peer’s submission
(in getting feedback from students they hint at this problem with peer
marking).

It is useful to examine some of the challenges with this form of formative
assessment. One challenge is that it relies on students wanting to do
more than just to ‘get by’ but to substantially understand and improve their
performance (Black and Dylan, 1998). Additional challenges involve an
examination of the psychological features of learning underpinning peer assessment, and of its relationship to the epistemology of courses studied. Though these may be embedded in the purpose of peer and other forms of formative assessment, they are not often explicitly stated (Yorke, 2001).

Despite these problems with peer assessment Knight (2001: 2) states that: ‘(it can be shown) conclusively that formative assessment does improve learning’.

Black and Dylan’s (1998) exhaustive study of formative assessment practices, predominantly in the schooling sector, involving over 500 studies in Europe, the USA and Israel identified from scanning the ERIC database, came to the same conclusions. They were able to show quantitative improvements in learning achievement where formative assessment principles (including peer assessment) were used.

One of the most persuasive examples of using peer assessment to promote learning and epistemological access comes from the description by Gibbs (1999). The intervention concerned students in a second year Engineering class in Britain. Initially, when numbers were small, students attended once-weekly problem classes in which they worked on a problem and submitted their solutions for marking and feedback to the lecturers at the end of the class. The end of course exam average was a respectable 55%. As numbers of enrolled students increased over time, so did the size of the problem classes; lecturers found it impossible to engage with all the students’ difficulties in the class, and to give substantive feedback later on student submissions. At the same time, the exam average dropped to a low of 45%.

The lecturers decided to drop the problem classes and instead requested that students bring once-weekly homework assignments to the mid week lecture. Instead of lecturing the lecturer went through a model answer to the problem set, and randomly distributed the homeworks amongst the students for peer assessment and feedback to one another. The students assessed against a model answer sheet but no marks were recorded. What was recorded for a ‘duly performed’ to write the exam was that the students had done 75% of the homeworks and attended 75% of the peer marking sessions.
After this intervention for the whole course, the average exam mark rose from 45–75%. Gibbs does not tell us how many students did not receive a DP but even so this is a substantial increase in the exam average, even compared to the original average of 55%.

This case study described here is similar to that of Gibbs but differs in that peer marking was conducted in tutorial sessions and the students were in first not second year.

THE STUDY AND ITS CONTEXT

The peer assessment study described here was conducted in the first year, first semester of an applied physics course, Mechanics 1. It was a collaborative effort between the Centre for Higher Education mechanics lecturer and tutors at a University of Technology. The course was what is known colloquially by lecturers as a ‘killer course’ as less than half the students passed the final exams and marks in weekly tests were also low, averaging around 45%.

Mechanics, being based on Physics, is a highly conceptual course. The focus of the lecturer in teaching the course was thus in getting students to understand the problems they were solving, rather than to just plug in formulas and do calculations. Students were encouraged to identify what sort of problem they were dealing with and what main principle and hence method underpinned solving the problem.

To this end the criteria for success in the course were the following:

1. The correct approach to a well-defined problem is chosen and justified.

2. The correct analysis and the appropriate principle in mechanics are selected for the task.

3. Formulae are correctly selected or constructed from the given unknowns.
4. The answer is correctly calculated and evaluated.

5. The answer makes sense within the context of the problem.

Students attended regular problem-solving tutorials where they would work independently or in pairs/groups on problems and the lecturer would demonstrate to the whole group how to solve the problems given. Students would be given a new problem as a test at the end of the tutorial. Some of these marks were recorded as part of their continuous assessment mark for the term.

In order to address the problem of fairly low achievement in the tutorial tests and final exam, two significant interventions were made. The first, by the lecturer, was to decrease the size of the tutorial classes and to make up the shortage of tutors by training and using students who had successfully completed Mechanics 1 course as tutors. The second intervention, which was only used over a period of three weeks, was to introduce peer marking.

Students were set once-weekly homework problems to solve, which they brought to tutorials. Only students who had evidence of at least having attempted the problems were permitted entry to the tutorials. Before the tutorial began the answered problems were handed in to the tutor; students did not have their own answers in front of them. This prevented students from ‘correcting’ their homeworks before they could be marked by their peers. The lecturer went through a model answer of the homework on the overhead with the whole tutorial group, and handed out a model answer on a printed sheet. During this period students questioned procedures and sometimes asked if the problem could be approached differently, as they themselves may have done. The students’ homeworks were then randomly distributed amongst the students in the tutorial group. Their task was to assess the homework of their fellow student against the model answer handed out. They were required to give written feedback comment on the procedure followed by their peer and to point out where things could or should have been done differently in writing on the script. Marks were assigned to the homework based on the model answer but these marks were not recorded.
Each student then sat with their peer and gave verbal feedback on their peer assessment.

Tutors were given a short description of the process to follow in peer marking, and why from the point of view of the lecturers it could add value to learning. Students were also briefed about the expectations (attempting the homework; giving one another feedback etc.) and that we were trying to get them to understand, through a process of peer marking, what counted as a valid attempt at problem solving.

EVALUATING THE PEER MARKING INTERVENTION

The first pointer we noted was a qualitative change in marks. Before the intervention test marks were averaging around 45% whereas around the time the intervention was being conducted marks rose to approximately 60%. Though they remained higher than usual they fell below 60% after the peer marking intervention ceased. However, we could not state with any certainty that this increase was solely due to peer marking as the start of this initiative coincided approximately with the change from large to smaller tutorials.

After the peer marking intervention students were asked to write a short comment on their feelings about the intervention. Altogether we received written comments from about half the class, 43 in all. Of these 21 were categorised as unequivocally negative about peer marking, 18 as positive and 4 as having both negative and positive comments; for example a negative/positive comment was:

Peer marking is important to students, to see different methods of solving a problem while they are marking their peer’s script. But I don’t like to mark my peers, it’s a waste of time to me and it’s supposed to be done by the tutors. They get paid so they must earn their money.
**EXAMPLES OF POSITIVE COMMENTS**

- It helps because one gets to see his/her mistakes and gets to understand the question asked better and be able to sink the concept for solving the problems.

- It is useful because one can see other methods of tackling problems from his/her peer and sometimes see common mistakes by your own peer.

- Peer marking is good because you get the chance to ask the marker why they marked you wrong. It makes you see where you need to improve. Chance of getting answers right is high.

- Peer marking helps a lot because it gives you the opportunity to see your mistakes. Discuss your mistakes and how you going to solve them with another student or tutor.

**Examples of negative comments**

- Peer marking is not good because we mark ourselves, we both don’t understand the subject and we can’t explain to each other why the other person is wrong. I would prefer that tutors mark the script.

- I don’t think it’s such a good idea. It’s better doing the work with the tutors that know the work. See no point in trying to figure out how other students approached the problem.
• This thing is not helping at all, it makes things worse and student does not know how to mark as a result we fail.

• Peer marking is completely a waste of time because you would find out that students mark without understanding the procedure, this results in marks awarded undeservingly.

DISCUSSION OF THE INTERVENTION

The negative comments mostly concerned students’ lack of confidence in their peers as sufficiently knowledgeable and accurate markers. The focus was thus on the quality of the feedback given. The positive comments focused on getting to understand how to do the problems through actually marking others’ work, seeing and understanding different approaches and through discussions (feedback) with their peers. The positive group are certainly indicating something of learning to understand the ‘rules’ of how to approach solving the problems given (‘sinking’ the concept). This contention is furthermore supported where students recognise different methods of solving the problem which can be understood as a more general, abstract understanding of solving this particular type of problem. In other words, internalising something about the epistemology of the subject that can then be used to guide their subsequent work (Biggs, 2003). In this sense students are also meeting some of the course criteria described earlier, for example choosing and justifying approaches and principles.

The problem lies with those students who do not see value in peer marking, which may be prompted by poor interaction and poor quality of feedback between those students. Alternatively this may be because these students are more concerned with ‘getting by’ than understanding the underpinning reasoning of problem solving in the subject (Black and Dylan, 1998). Whatever the reason, students would need to be inducted into the reasoning behind the peer marking process and that it is not just about the quality of feedback but also that they engage with trying to understand how to go about solving problems.
CONCLUSIONS

The point of showing this case description has been to illustrate how the process of peer marking may help students gain epistemological access to Mechanics. This is inferred from students’ comments about seeing and understanding their own and others’ mistakes, which itself derives from an understanding of what counts as an appropriate approach to solving Mechanics problems (and there may be, as students describe, more than one way). Students begin to ‘internalise criteria for quality’ (Biggs, 2003: 47). As one student points out, it is not just marking that is involved but ‘discussion of mistakes’; as Yorke (2001) suggests, it is this sort of dialogic process in formative assessment that can lead to students gaining better understanding of their subject matter.

What would help in future work would be to examine more closely the sort of problems set for students, the nature of appropriate answers, the nature of students’ actual answers and the calibre of feedback given to one another based on peer evaluation of these answers. A stronger case supporting peer marking as an epistemological access tool could then be made. Furthermore, the case study is not just about the act of peer marking but a series of engagements with the subject matter. The students first do the problem on their own, then listen to and interact with the tutor giving the model answer. This is followed by the students assessing one another on their own which is in turn followed by a feedback session involving discussion of the mark awarded.

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LEARNING IN AN ANATOMY CLASS IN NURSING

Penny Gill

INTRODUCTION

The ever increasing epistemological gap between secondary and higher education has resulted in a low throughput rate in the national four-year integrated Nursing Diploma offered by the Western Cape College of Nursing (WCCN) in collaboration with the Cape Peninsula University of Technology (CPUT). The ever-increasing gap is having a detrimental effect upon the availability of newly registered nurses in the Western Cape. WCCN and the University of the Western Cape are the only institutions offering the four-year degree/diploma course in nursing in the Western Cape.

In 2008, with this acute shortage in mind, an Extended Curriculum Programme (ECP) was implemented at WCCN within the first-year Department of Nursing to run concurrently with the mainstream programme. The ECP was structured to run over two full academic years. This strategy has been successfully implemented in 27 departments at CPUT. According to Kloot et al (2007), a foundation programme (ECP) is designed to provide a special programme for students whose prior learning has been affected by educational and social inequalities. According to Fundani (2010) the teaching philosophy behind the ECP is one of intensive teaching of the mainstream subjects in order to provide access to the ways of doing and thinking in those subjects and in the field as a whole. In short it provides relevant epistemological access to students.

This paper reports on a classroom and field instruction project at the Western Cape College of Nursing in an Extended Curriculum Anatomy and Physiology class. The aim and purpose of the class was to promote epistemological access by using active learning to produce a more
effective outcome with less reliance on rote learning of the prescribed text. The role of the biological and natural sciences in nursing as well as learning and epistemological access will be discussed. Two activities will be described as well as a discussion and reflection on what was learnt.

**THE ROLE OF THE BIOLOGICAL AND NATURAL SCIENCES IN NURSING**

**Western Cape College of Nursing**

At the Western Cape College of Nursing, the biological and natural sciences are taught on an applied level and constitute a substantial part of the scientific knowledge base required for informed and competent nursing practice. The requirements for coursework in Anatomy and Physiology, for example, serve as a framework or foundation for the clinical intervention nursing course work that follows. Despite having Biology / Life Sciences as a Matriculation subject requirement, these courses remain a challenge to students and a high failure rate is experienced. The students need to learn a whole new language of medical terms together with complex information regarding the way the body functions and is structured. The students have the added burden of having to grapple with these complex prescribed texts in a language which is not their mother tongue.

**Bioscience in nursing**

Traditionally nursing has drawn heavily from various sources of knowledge, such the social, behavioural, medical and biological sciences, to construct a unique body of nursing knowledge and to produce a reflective, creative practitioner who is able to think and use her analytical skills to provide patients with the highest quality nursing care possible (Trobanskj, 1993). It is further stated by Tmobranski (1993: 498) that biological sciences are essentially experimental subjects, but in the context of nursing they are taught exclusively theoretically and nursing students are expected to acquire complex, abstract scientific concepts without immersion in practical discovery. It is no wonder then that students have difficulty in seeing the
relevance of the knowledge transmitted in lectures for the tasks they are expected to complete in the practical ward situation.

**Influence of behavioural sciences on nursing**

According to Jordan (1994), nursing has been heavily influenced by behavioural sciences in the development of its own unique professional body of knowledge. The author, a medical doctor who teaches nurses, is of the opinion that nursing theory favours the behavioural sciences when in fact the practice of nursing is devoted to problems of biological disturbance. Jordan (1994) emphasises that this could lead to nursing facing a widening theory-practice gap, greater than other professions. Jordan and Reid (1997) state that there is a presumption that biological and natural sciences will assist nurses to understand and give meaning to the student’s comprehension of pathophysiology and applied clinical procedures (as cited in Johnston, 2010). In relation to anxieties regarding learning the biological sciences, Jordan et al (1999), in their study of staff and students’ perceptions of the difficulties and relevance of the biosciences in pre-registration nursing curricula, found that students reported that the biological sciences were very difficult to learn and caused them considerable anxiety.

**South African context**

Kyriacos et al (2005) state that the transforming and democratising of higher education in South Africa has led to increased access to higher learning with the embracing of a policy of inclusivity. This has major implications and challenges for nursing education especially in the biological sciences. The majority of students come from a historically disadvantaged education system. According to Lange (2007), poor student outcomes are shaped by the following issues: the general lack of preparedness of students and staff; the nature and organisation of teaching and learning at higher education institutions; the conceptualisation of the educational process, particularly in terms of the appropriateness of content and assessment methods and its relationship with different institutional cultures; the extent or lack of
professionalisation of academic staff; the nature and extent of funding; and the role that system differentiation might have in addressing under-preparedness. Scott et al (2007) argue further that it is essential to come to terms with the profile of the student body and they need to be catered for effectively. If this is not done there will be a constant mismatch between what can be offered and what the students actually need to facilitate their learning. Scott et al go on to say that if we accept the challenge it could be a stimulus for creative initiatives and make a big difference to the outcomes in our education system.

**LEARNING AND EPISTEMOLOGICAL ACCESS**

Clarence (2009: 19) states that ‘students need to understand their discipline’s “epistemological core”’, in other words ‘the kind of knowledge valued by the discipline’. Morrow (2009) speaks of ‘learning to become a participant in an academic practice or gaining access to the practice in question’.

Morrow (2009: 78) further relates that epistemological access is not a product that could be bought or sold, given to someone or stolen; nor is it some kind of natural growth, such as the growth of plants or bodies. Epistemological access cannot be supplied or ‘delivered’ or ‘done’ to the learner; nor can it be ‘automatically’ transmitted to those who pay their fees, or even to those who also collect the handouts and attend classes regularly. McKenna (2009) likens the practice of epistemological access to that of joining a tribe. The tribe which a new student is trying to become a member of does things very differently. In order for this student to be accepted the student needs to crack the code. They have to use the same literary practices as the tribe they are trying to join. Many students fail to do this and according to McKenna (2009) 56% of the student’s cohort will have dropped out with him/her (as cited in Scott et al, 2007).

According to Morrow (1993), we need to put our emphasis on ways of developing our teaching practice by focusing on trying to understand the difficulties students experience as being related to a lack of access to
covert rules of academic discourse, (as cited in Boughey, 2002). This would result in making the rules and conventions of academic ways of thinking, valuing, acting, speaking, reading and writing more evident to students, (Boughey, 2002). Boughey illustrates this concept further by saying that:

Literacy is not something which can be overtly taught in a convenient introductory series of lectures. People become literate by observing and interacting with other members of the discourse until the ways of speaking, acting, thinking, feeling and valuing common to that discourse become natural to them. (Boughey, 2000: 6)

Using McKenna’s analogy of having access to and joining the tribe (McKenna, 2009), the student needs to learn this new language to become part of the profession of nursing. The student needs to be able to use this new language specifically when learning the biological and natural sciences and when assessing patients and in documenting nursing interventions: the student cannot document that ‘the patient has a pain in his tummy and leg’. The student needs to be precise and use the medical terminology she has gained within the discipline and be specific: ‘the patient has an acute pain in the left iliac fossa radiating down the left leg’. The biological and natural sciences have their own language and terminologies so the student is doubly disadvantaged.

Struyven (2006) states that ‘student-activating teaching methods are intended to challenge students to acts of knowledge construction rather than knowledge acquisition and, consequently, deepen student learning beyond the levels of reproduction and rote learning’.

FROM PASSIVE TO ACTIVE LEARNING

Having taught the biological and natural sciences for a number of years I have become increasingly aware that the course offers many challenges to
the students. As the size of the student groups increases, so cost-effective teaching strategies have become a way of life. One of these strategies, the traditional lecture method, engenders a passive learning approach which has now become firmly entrenched as the numbers of nursing students increase due to the national and local demand for more nurses. I will now examine traditional teaching, superficial and deep learning and active learning in a little more detail.

**Traditional Teaching**

Gwele (1998), in a study carried out amongst nursing educator students, stated that traditional teaching does not look at how nursing students learn. She related that students are of the opinion that the work that is presented must be memorised and regurgitated back according to what is in the examination memorandum. On the other hand educators using this system are under the impression that they must physically teach every last word in the curriculum. Gwele further states that, when the SA Nursing Council launched the new four-year professional qualification in 1985, it was firmly stated that there should be an emphasis on self-directed learning, and analytic and critical thinking skills. Despite this legislation the traditional lecture is still one of the vehicles nurse educators use the most to convey information to their students. The lecture method will always be an important conduit for the relay of information but must be used judiciously. Biggs (2003) is of the opinion that traditional teaching delivers information to students with very little regard to the usage of this information. He goes on to say that students are in a passive mode of learning and this does not bring about engagement with the learning material and facilitate deep learning.

**Surface Learning**

According to Trigwell and Prosser (1991), surface learning is used in an attempt to rote learn in order to reproduce the material at a later date. Biggs (1999), Entwistle (1998) and Ramsden (1992) state that students attempt to take on new work without questioning and store it away without attempting to link the various items to previous knowledge.
Spencer (2003) believes that students who use the surface approach often fail to see the subject relevance and may be motivated by fear of failure. This is seen particularly in the biological and natural sciences. Biggs et al further state that information is received passively without focusing on the principles. Students are not able to apply what is being learnt in the biological and natural sciences with what is being taught in their fundamental nursing subject. They only view coursework as content for an exam paper, not for lifelong learning. They study for a qualification and not for the love of the knowledge and the benefits of that knowledge to their chosen career. They focus on remembering the facts and look at them as being unrelated and of no real interest. They spend large amounts of time on rote learning and not enough time on understanding the course work and its relevance to their practice. Entwistle (2001) goes on to say that routine, unreflective memorisation and procedural problem solving are associated strategies with restricted conceptual understanding being the inevitable outcome. This becomes patently obvious when one is grading exam papers and a student has rote learned a section without understanding the basic concepts and the relationship of the various concepts. Often what is documented makes no sense whatsoever.

**Deep Learning**

Marton and Säljö (1976) first introduced the idea of deep learning. According to Biggs (1999), Entwistle (1998) and Ramsden (1992), in deep learning information is critically examined and structured with various ideas being linked. Meaning is pursued and there is a focus on concepts. There is active interaction with a difference between argument and evidence. The student will see connections between various subjects and build on previous knowledge. The student is interested in the subject and shows good time management. Trigwell and Prosser (1991) agree with the above in relation to students who use the deep learning approach seeking meaning in order to understand. Entwistle (2001) emphasises the fact that this approach is associated with the intention to comprehend and to undertake active conceptual analysis.
Jordan and Reid (1997) found that nurses are often unable to relate biological sciences to their work (Clancy et al, 2000). According to Haggis (2009), despite increasingly varied range of models and theoretical approaches to understanding how students learn, the basic ideas are still mostly based on the research on deep and surface learning done by Marton and Säljö in the 1970s or just taken for granted. Haggis (2009) goes on to say that despite this research being undertaken there are difficult questions about the universities themselves. The focus has been on the cognitive processes of the individual students and why the students are still not engaging in learning the way their lecturers want them to. The reason for students preferring surface learning to deep learning has remained mostly undiscovered despite intensive research over the last 40 years.

Active Learning

Chickering and Gamson (1987) state that learning is not something you can just sit and watch. Students need to become involved as they do not learn much just sitting in classes listening to teachers, rote learning and spitting out answers. They need to talk and write about what they are learning and relate it to their past experiences, and apply it to their daily lives. What they learn must become part of themselves. This is of particular importance in the biological and natural sciences where students need to use this knowledge to understand how the body is structured and how it functions in health so that they can understand how the body is structured and functions in illness.

Paulson and Faust observe that active learning is anything that students do in a classroom other than merely passively listening to an instructor's lecture. This can include listening practices, writing exercises and complex group exercises. Active learning equals activity in the classroom. The learner constructs knowledge rather than passively receiving it, shaping it, as well as being shaped by experience. (Paulson and Faust, 2008).

THE LEARNING ACTIVITY
Due to a mounting sense of frustration with my students’ constant inability to ask and answer questions and their dependence on rote learning I felt I needed to approach my teaching and the students’ learning differently.

When I asked if there were any questions during and after a presentation the students would appear uncomfortable, nervously look around and cast their eyes downwards, and there would be the usual refrain of ‘No, Miss’. As an experienced teacher this really bothered me and I questioned how I could engage the students on a deeper level. It became increasingly clear to me that they do not know what they do not know. How could I change the environment from a classroom with a ‘passive teacher who knows it all and pours it into empty vessels mode for regurgitation at examination time’ to an active classroom where a deeper level of learning was taking place? According to Duncan (2006), ‘Two of the oldest and most fundamental challenges in education are how to engage students and how to determine if they are learning what you are teaching’.

With this in mind I decided to start in an anatomy class I was about to present on the structure of the heart. I set about designing an activity that would:

- Make use of active learning to promote epistemological access and promote deep learning;
- Help the students build on previous experience of learning the structure of the heart at school;
- Value the relevance of learning about the heart in order to be able to understand blood pressure, locate pulses, administer CPR and nurse patients with heart disease;
- Encourage group activity and cohesion; discourage meaningless memorisation of facts by assembling the content in an orderly systematic way; bring activity and movement into the class environment; allow students to act out their own personal visual
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reality of the structure of the heart and blood vessels; give meaning to the prescribed text; encourage creativity amongst the students; engage the students actively in critical thinking, problem-solving and reflection;

• Conclude the exercise with a quiz using the audience response system (clickers) to assess the students’ understanding of the basic structure of the heart anonymously to encourage participation; pause for reflection of the exercise and comment on whether they felt learning had taken place and how they experienced it.

There were two activities carried out. The first activity involved 37 students in ECP 2 2011 and was completed in May. The second activity was completed in July with the ECP 1 2011 class of 46 students.

The first activity was teacher centred and the second one was self-directed and student centred. For both activities the students were required to read the prescribed text on the anatomy of the heart and dress in either red or blue clothing to depict the oxygenated or deoxygenated blood

Activity 1

The students were briefed in the classroom and then taken outside to the garden and given a short explanation regarding the aims of the activity. The outside structure of the heart was built by the students joining hands and standing in the shape of a heart. The various layers of the heart were demonstrated with the students forming a double layer to represent the two layers of the pericardium. The muscle layer was demonstrated by movement of a constrictive heartbeat. The students were then led to form the four chambers and the various vessels entering and leaving the heart were demonstrated. Lastly the students dressed in blue were walked through the right side of the heart tracing the pathway of deoxygenated blood through the right side of the heart and through the pulmonary circuit. Students dressed in red were then walked through the left side of the heart tracing the oxygenated blood through the left side of the heart and through the systemic system. The students then went back to the classroom where they were tested by 15 questions on the work that had been covered outside.
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This was presented on a PowerPoint presentation especially designed for the exercise. The answers were collated anonymously by an audience response system (clickers). A reflection exercise was carried out on the activity.

**Activity 2**

The second activity was student directed and focused. Two days before the activity the students were prepared as follows. They were given a written outline of the relevant outcomes and tips on how to go about the activity without receiving too much information which might have stunted their creativity. The learning activity was aimed at involving students in a ‘hands on’ approach where they acted out their own personal visual reality of the structure of the heart, blood vessels and the pathway of the blood through the right and left side of the heart. The students were asked to translate the medical text to a more vibrant acted-out form, which involved intensive movement and use of the special senses of sight, sound and touch. In other words, as emphasised by Struyven (2006), ‘Student-activating teaching methods are intended to challenge students to acts of knowledge construction rather than knowledge acquisition and, consequently, deepen student learning beyond the levels of reproduction and rote learning’.

At the appointed hour 46 students gathered in a grassed area outside the classroom. One of the students acted as a narrator and led the students through well-choreographed movement and role play depicting the three layers of the heart, four chambers of the heart and the various blood vessels entering and leaving the heart.

They also included electrical conduction of the heart where students showed how electrical impulses moved through the heart. Finally, some students dressed in blue actively traced the flow of deoxygenated blood through the right side of the heart and through the pulmonary circuit. Students dressed in red then traced the oxygenated blood through the left side of the heart and through the systemic system. The students then went back to the classroom where they were tested by 15 questions on a
PowerPoint presentation. The answers were collated anonymously by an audience response system (clickers) and a reflective exercise took place.

**Reflections - what did we learn?**

The students embraced the two projects with enthusiasm. According to Duncan (2006), ‘those who have aspired to Carl Sagan’s model of inspired teaching, might find it difficult to accept that students learn significantly more if during a class we the teachers are completely silent and allow the students to do the talking, thinking and teaching’. Duncan (2006) showed this to be a fact in a study he did of 6000 students in 62 physics classes.

**Activity 1**

The students enjoyed the activity. Suddenly there was noise, excitement and activity. During the activity as we moved around the inside of the imaginary heart you could see intense concentration on a number of faces as they were thinking and applying and visualising what they had read in their textbook. It was beginning to make sense and they were trying to understand what was taking place. When the questions that I posed were incorrectly answered I could offer an immediate correction by showing the student, within the student-made structure of the heart, the correct answer. I could see that they were seeing the structure of the heart from a totally different perspective. After the exercise we returned to the classroom where they were examined on the topic with a PowerPoint quiz and with an introduction to the clicker system. During reflection on the exercise the students gave the following comments:

**Heart Exercise**

- I had to think about the heart differently from the picture in the book
- I liked it, it was a fun way to learn
- It made the heart come alive
• It showed me where the valves were and how they worked

**Clickers**

• If I give a wrong answer nobody will know it is me
• I am shy and this helped me a lot
• This was fun, when are you using them again.

These comments support the research done by Gashago et al, (2010) that clickers are fun, create a safe environment, encourage peer-to-peer learning and lastly develop students' critical thinking skills.

As I reflected on the exercise I decided that, even though learning was taking place, I needed to do the exercise again but this time allow the students free rein to design and role play to create their own meaning of the structure of the heart and not mine.

**Activity 2**

In the couple of days before the scheduled activity one student voiced her anxiety regarding the activity on their Facebook group page, (ECP 1, 2011): direct quotes, grammar and spelling not changed.

• oh I'm so on my nervous for the blood flow I Dnt understand why its still so difficult 4 me 2 understand I try bt I jstDnt get it

Post Activity ECP 1, 2011. (Original grammar and spelling).

• I had fun today, didn't think it was gonna turn out so good. I had my worries at the beginning of the practices, but am glad we pulled through!! Well done ECP1 2011!!!

• After today i feel like i really knw the heart, it really helped me a lot bczi amone of the visual leamers and this is going to stick on my mind forever. Thank u very much Mrs Gill
• Beautiful performance we did by the pool guys, LET'S MAKE IT LAST.

• dat was so great tankx a lot to everyone 4 participation

• I liked being the inferior vena cavae.

• I like being the tricuspid valve when its open.

• ohguyz u did very well and i hope it waz nice for everyone, we learn a lot and we thank God with our supportive lectures mrs Zmrs Gill

• guyzive gained alot today thank you to our lectures mrs peteresen, gill, trish and fellow students for the team work.

The students were creative and well rehearsed and showed evidence that they had engaged with the coursework and constructed their own meaning of the heart. The exercise was completed by a quiz on the structure of the heart using an audience response system. The result of the quiz was 80.6% for the ECP 1 Class of 37 students and 80.4% for the ECP 2 class of 46 students. I may have unintentionally skewed the results in this class by inviting some guest lecturers to observe the class. They were given clickers to participate. Towards the end of the quiz the students thought they should have been doing better and actually challenged the 4 guest lecturers and asked them to refrain from voting as they felt they were giving incorrect answers and preventing them from doing well.

**DISCUSSION**

How do we provide a holistic learning experience? How do we facilitate and structure learning in the anatomy class that has meaning in the student’s future career in nursing? In other words, how do we create the beginnings of epistemological access for our students? I believe we have to change our approach from a traditional one that emphasises teacher-centred lectures, note taking and passivity in the classroom to an approach that engages the student actively and critically in the process of learning.
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(Boyd and Herzog, 1997). Both the role plays and use of clickers were attempts to do this.

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