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Shifting to Active Learning: Assessment of a First-Year Biology Course in South Africa

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Large first-year class sizes have resulted in many lecturers adopting coping strategies consisting of direct-transmission mode teaching, reduced practical time, and assessment. Recently several strategies have been implemented in an attempt to improve student participation and active learning; however, these changes have to be facilitated and fostered by faculty and administrators. Consequently, we present the implementation, results, and feedback of a new Biology first-year course run for the period 2005-2008. In this course, the number of lectures was reduced, and the number of more co-operative tutorial and practical-based sessions was increased. The aim of these changes was to promote active participation of students and to encourage them to take responsibility for their own learning. Despite some initial problems, most students and staff were positive about the learning experience, and the skills developed were considered of value to other science courses. Other courses are encouraged to follow this example and move to a reduced lecture and increased interactive tutorial/workshop and practical approach to promote student learning and development.

There is pressure to increase student access to tertiary education, yet still maintain standards and retain students (Rust, 2002). Related to this is the need to raise standards and improve efficiency, as well as enhance student learning (American Association for the Advancement of Science, 2009; Hockings, 2005; Jones, 2007). Consequently, there is much discussion about the size of first year and introductory courses and the conditions necessary for effective teaching and learning (Goldfinch & Hughes, 2007; Hockings, 2005; Jones, 2007; Preszler, 2009). Currently with increased content to learn, improved access to facts via the Internet, the demand to apply conceptual knowledge, and the anticipated use of problem solving skills in career experience after graduating from the university, students need an education that promotes these abilities rather than one that promotes merely the memorizing of facts (Knight & Wood, 2005). The problems of teaching and learning science, as well as the solutions to these, have been around for 200 years, but they have had little impact on classroom practice (Wright & Klymkowsky, 2005).

Most large first-year science courses follow a traditional lecture mode and contain a laboratory component (Alghasham, 2012; Handelsman et al., 2004). Unfortunately, the laboratory component is often not innovative or inquiry- or research-based (Weaver, Russell, & Wink, 2008). Although the lecture approach can be used as an instrument of inspiration, it has severe limitations as a teaching tool if there is no student engagement and interaction (Fernandez-Santander, 2008; Jones, 2007). There needs to be implementation of alternative approaches that are more effective at fostering and developing conceptual and scientific understanding or reasoning, active student participation, and assimilation (Exeter et al., 2010; Fernandez-Santander, 2008; Handelsman et al., 2004; Preszler, 2009; Ueckert, Adams, & Lock, 2011). Implementing change requires active student participation in lectures, reduction in lecture time, and an increase in more cooperative tutorial and discovery-based laboratory tasks in order to encourage student participation in, and responsibility for, their learning (Allen & Tanner, 2005; Exeter et al., 2010; Fernandez-Santander, 2008; Handelsman et al., 2004; Weaver et al., 2008). Some reluctance to reform teaching results from the large class size and the perceived reduction in specific content covered (Allen & Tanner, 2005; Freeman, Haak, & Wenderoth, 2011; Handelsman et al., 2004; Knight & Wood, 2005).

This reluctance to change is despite the research (neither isolated nor discipline-specific) that has shown that student learning and knowledge acquisition are enhanced with an interactive approach to lecturing (Allen & Tanner, 2005; Andrews, Leonard, Colgrove, & Kalinowski, 2011; Handelsman et al., 2004; Hockings, 2005; Knight & Wood, 2005; Meltzer & Manivannan, 2002; Thornton & Sokoloff, 1998). However, some courses or modules have gone to the extreme of replacing lectures almost entirely (Handelsman et al., 2004).

In the large classes typical of first year courses, the process of reform in teaching—or more specifically, the process of translating these into practice—is daunting. Lecturers who do attempt to promote student participation and learning are often met with resistance from an unexpected source, the students themselves, as emphasis moves from memorization and recall to the development of critical thinking and the skill and ability to undertake self-directed learning (Allen & Tanner, 2005). However, changes need not be rapid, but rather incremental with partial shifts, and they should start small but should be introduced early (Knight & Wood, 2005; Wood, 2003).

Conceptual understanding in biology requires comprehension of scientific terms, the ability to transfer information, and a working awareness of scientific knowledge and practice (Klymkowsky, Garvin-Doxas, & Zeilik, 2003). There is general support that first-year biology courses should have educational objectives that prepare students to function as scientists and educators in a broad array of biological disciplines.

A number of strategies have been used to facilitate the implementation of *active learning* teaching (Alghasham, 2012; Allen & Tanner, 2005; Fernandez-Santander, 2008; Preszler, 2009; Weaver et al., 2008). These strategies can include structured question-and-response techniques and/or involve students in researching and writing reports on delegated topics (Allen & Tanner, 2005). Allen and Tanner (2005) suggest the use of a learning-cycle instructional model in order to overcome students' concerns and doubts about a more active learning approach. This is a scaffolded sequence of tasks that assist students in developing their conceptual understanding and their ability to transfer knowledge. Another approach that also addresses students' concerns is the use of senior students to guide and facilitate discussion and to give feedback (Allen & Tanner, 2005).

The active learning strategies that have been developed and implemented successfully in large first year biology courses require curriculum change and usually new approaches to teaching. As most of these courses are taught by more than one lecturer during a semester, it also requires that all those teaching the course adopt the change and move from the more familiar and perhaps comfortable *teaching as we were taught* approach (Allen & Tanner, 2005). This requires a mind-set change that understands teaching efficacy as how many students engage in deep and meaningful learning (Allen & Tanner, 2005). Lecturers need to be convinced that learning is based on discovery and guided by mentoring and transmission of insights (Wood, 2003).

In 2005, in the context of the *active learning* teaching, we developed a new biology first-year course at the University of KwaZulu-Natal (UKZN) in the School of Biological and Conservation Sciences (SBCS) to run parallel with the current first year course. The proposed instructional mode was different from most other first year courses in the Science and Agriculture Faculty, UKZN. The new mode mimicked one used successfully in foundation courses at UKZN and other biology courses attempting to enhance teaching and learning using an *active learning* or *student-centered* approach (Allen & Tanner, 2005; Kumar, 2005; Miller & Cheetham, 1990; Wood, 2003) to encourage students' participation and responsibility for their learning. One of the main purposes of the course was to scaffold the development of science process skills in a biological context. It was hoped that students would acquire the fundamental practical and cognitive skills necessary for study in the life sciences, as well as develop a foundation in biological concepts and awareness. It was also hoped that students would be exposed to scholarly scientific and technological advances that affect the changing needs of society. Another important aspect was to develop the students' approach to problems and the process of the scientific method. The following describes the implementation of a practical-based first-year biology course which was introduced on two different campuses and included reduced lecture and an increased tutorial.

Methods

During the second semester of 2005 and 2006 at UKZN, the SBCS ran a course, "Hot Topics in Biology," on the Pietermaritzburg (PMB) and Howard College (HC) campuses. Originally this was a 16-credit, whole semester course but was reduced to an eight credit course in 2007. The course design, implementation, and assessment were documented for the period 2005-2008. Students and staff were asked for comments about the course. The students' comments were made as a response to an evaluation form which they completed at the end of the course. Budgetary and other constraints were also documented. Performances of students were analyzed and compared.

Course Design, Implementation, Teaching, and Assessment

It was decided to move from the traditional four lectures and one practical per week course to one with fewer lectures and increased interactive tutorials and practicals (the proposed outcomes of the course are shown in Table 1). The explicit skills development for 2005 and 2006 during tutorials is shown in Appendix A and during practicals in Appendix B. The skill development was reduced when the course was reduced to eight credits in 2007.

Although three formal lecture periods were assigned each week, only two of these were used with the third allocated for library or assignment time. Each lecturer was allocated three to four weeks with the class during the semester. Generally, the two lecture periods were used to cover topics in an interactive mode and not a formal instructional mode (see Appendix A). These lectures were scaffolded with topics for discussion and explanation, as outlined in the manual that the students received.

Two more practical-based sessions were assigned per week: a double period tutorial that was held in the laboratories (see Appendix A) and a three-hour practical session (see Appendix B). During the tutorials

Table 1
Outcomes and Their Assessment in the "Hot Topics in Biology" First-Year Biology Course

Student Outcomes	Practical Reports	Assignments	Tests	Portfolio	Practical Examination (3h)	Theory Examination (3h)
Have a **foundational** understanding of the scientific basis of important contemporary issues of a biological nature facing humanity and how these interrelate	√	√	√	√	√	√
Have learned basic skills in managing and organizing information	√	√		√	√	
Have learned basic skills in sourcing information relevant to different topics which includes discerning use of the internet	√	√		√		
At a basic level can find, read and critically evaluate original scientific literature	√	√	√		√	√
At a basic level can analyze, interpret, and present scientific information or data	√	√	√		√	√
At a basic level have developed skills in asking questions, generating testable hypotheses, designing investigations/ approaches to test them, and interpreting the data from those tests to reach valid conclusions.	√	√	√		√	√
At a basic level have developed oral and written communication skills	√	√	√	√	√	√
At a basic level are able to work independently	√	√	√	√	√	√
Have developed basic interpersonal and team-working skills	√	√				
At a basic level have developed personal opinions and ideas while acknowledging and respecting the views and opinions of others	√	√	√	√	√	√
At a basic level are able to place their work in a broader scientific context.	√	√	√	√	√	√
At a basic level have an awareness of important moral and ethical questions in a biological context	√	√	√	√	√	√
At a basic level are able to express personal responsibility for their actions	√	√		√		
Have begun to show adherence to accepted standards of professional and ethical behavior	√	√	√	√	√	√
Have begun to relate what they have learned to their own life experiences.	√	√	√	√		

(see Appendix A) students were involved in, and completed, a range of designated tasks. Although a lecturer was present, postgraduates acted as demonstrators or tutors (hereafter called facilitators) that facilitated group work. On the PMB campus each facilitator was assigned a maximum of 15 students. However, initially on the HC campus, each facilitator was assigned groups of up to 60 students, which created problems. However, in the second half of the course, this approach was amended to that described for the PMB campus.

Cooperative learning was facilitated through formal group work with the emphasis on peer teaching and individual accountability. A tutorial topic was scaffolded by relevant questions; direct learning resulted from group discussions that were then supplemented by readings and notes. Tutorial sessions differed in their foci with some concentrating on development of aptitudes including essay writing skills, interpretation of diagrams, interpretation of scientific text including textbooks and papers, comprehension, and understanding of tasks. Other tutorials included analysis of video footage, analysis of quantitative and qualitative data, and discussion or debate on the various topics. Another important aspect of these tutorial periods was the time dedicated to addressing problems that students had with the previous practical so that they could benefit from, and act on, the comments of the facilitators. Every student was expected to prepare for these tutorials. Tutorials included group discussion and individual consolidation through written exercises (see Appendix A).

The teaching methods used in the practical component of the module may be described as hands-on. Students engaged in skills-based, guided discovery learning (students worked in small groups with a facilitator) during the laboratory sessions. Library work and field trip experiments were central to investigative learning (see Appendix B). The “hands-on” approach was also used on the field trips where students enjoyed real biological experiences in groups small enough to develop interest and promote communication and interaction with mentors and postgraduates.

As a consequence of the teaching philosophy adopted for this course, the facilitators played a pivotal role during practicals—especially in the assessment of the students’ work after each practical—in providing feedback, encouraging discussion with students, and with assisting on field trips. Many of these facilitators acted as mentor figures to the students as well. Similarly, as Wass, Harland, and Mercer (2011) observed, there were many benefits to using facilitators. The pre-practical preparation and management of facilitators was important. Facilitators attended a general training course at the beginning of the course, and thereafter, they attended weekly pre-practicals where they were provided with detailed mark sheets to scaffold their marking and to ensure standardization of marking. Feedback from facilitators was useful in determining the dynamics of the course.

Independent study was encouraged through research and essay exercises, as well as through the use of the course manual. The course was scaffolded with a manual in the form of a file that had a lecture/tutorial section and a practical section. The content of the tutorial section was covered in the allocated lecture periods and tutorial double-periods. Pre-reading and preparation for tutorials and practicals was expected of the students. There were four units which represented the biological topics to be covered. Each unit had basic notes and diagrams that summarized key information, and it also had questions that needed to be answered by students as well as questions designed to drive discussion. Readings and articles of interest pertaining to the topic were made available to the students.

Expectations of student performance were explicit from the start, and the process and criteria for assessment were made transparent. Conceptual understanding and reasoning skills were assessed in class tests and theory examinations. The course class mark contributed 33.3 % to the final grade and included practicals, theory assignments and tests, and a portfolio. The final examinations made up the remaining 66.6 % of the final grade and were comprised of a theory paper (50 %) and a practical (50 %). The practical component focused on the students’ acquisition of processing skills and was assessed using data response questions. The practical component also included a set of questions designed to assess students’ microscopy observation and drawing skills and was assessed in their production of detailed drawings.

Results

Course Implementation

The course was run on two different campuses. The HC campus had more students (2005: n = 151; 2006: n = 122; 2007: n = 130) who were biased towards medical science whereas student numbers on the PMB campus were lower (2005: n = 69; 2006: n = 55; 2007: n = 34) with a more agricultural/biological science bias. Those lecturing the course on the PMB campus were more involved in the development of the course and were therefore more accepting of the change.

Course Evaluations

There was a range in students’ responses to the course, and these differed according to campus. In 2005, HC students felt they were ill prepared for examinations and were concerned they had not achieved as well as the parallel biology course that was less skills-based and more content-based. However, students were more positive in subsequent years. Course evaluation results of PMB students in 2005 are summarized in Appendix C. Responses for subsequent years were similar. Most PMB students found that the course had benefitted them, and they particularly enjoyed the alien invasive section as well as the lecturer responsible for that section.

Student Performance

Overall, in the years 2005-2007, most students performed well enough to pass the course. The distributions of final marks for both campuses in 2005 (see Figure 1) were similar to subsequent years. Although the failure rate was low, few students excelled with only a few students achieving marks above 80 %. Despite this, it was clear that most students had developed some degree of skills. The small class size and enjoyment of the alien plant section likely contributed to the higher pass rate on the PMB campus.

Discussion

Buying into the Course

We implemented a course with fewer lectures but with additional group work tutorials and research-based practicals. Students were more actively involved in the learning process but also scaffolded to develop the basic skills needed to function as scientists and to develop discipline-specific information fluency. In particular, they were exposed to scientific papers, and their biological literacy was developed during tutorials and while writing essays and research reports. We found there was still a role for lectures, but that these could be reduced in number to allow for additional interactive tutorials/workshops. Facilitators who led the students in mini-groups played an important role in assisting with assessment, as well as in developing the students' confidence.

In many first year or introductory courses with large class sizes, lecturers give well-prepared lectures, handouts and model answers, but most students still show poor response in terms of problem solving, are focused only on getting the answers and marks, show little critical engagement, and accept little responsibility (Hockings, 2005). Transforming to a student-focused approach requires the redesign of a module, its implementation, and its assessment. Elsewhere course restructuring to ensure active learning in undergraduate first year biology has improved students' learning, attitude, and performance (Armbruster, Patel, Johnson, & Weiss, 2009; Freeman et al., 2011; Preszler, 2009).

As mentioned earlier, conditions for effective teaching and learning when a student-focused approach is adopted are often hindered by the institution's policies and practices, students' and lecturers' perceptions, and the reluctance for change (Hockings, 2005). These barriers include the following: (a) the students' experiences, beliefs, and expectations of learning, teaching and assessment; (b) class size and diversity; and (c) assessment demands, workload, and over-bureaucratic quality procedures (Hockings, 2005).

Initially, the management of the SBCS and the lecturing staff involved in developing the module from the outset were supportive. However, once the module had been developed, some lecturers showed reluctance, and many of these resorted to teacher-focused strategies as a coping mechanism. Some students, particularly HC students, also showed reluctance to a change to this non-conventional module. Many of their comments emphasized their surface learning attitudes and habits. It is perhaps overly optimistic to hope to change the student culture or habits across the whole cohort when transforming a module to a student-focused one (Hockings, 2005; Knight & Wood, 2005).

Interestingly, one of the main opponents to this new biology course at UKZN have been faculty in other disciplines who perceive that biology has an extra first-year course and should not have this advantage. However, many of the topics covered and skills developed are actually interdisciplinary and would benefit their courses as well. This interdisciplinary approach is not new, but rather is highlighted in the report for changes in undergraduate biology in the USA, *Bio2010: Transforming Undergraduate Education for Future Research Biologists,* that examined ways to integrate mathematical, physical, and information sciences into the education of undergraduate biology students (Brenner, 2003).

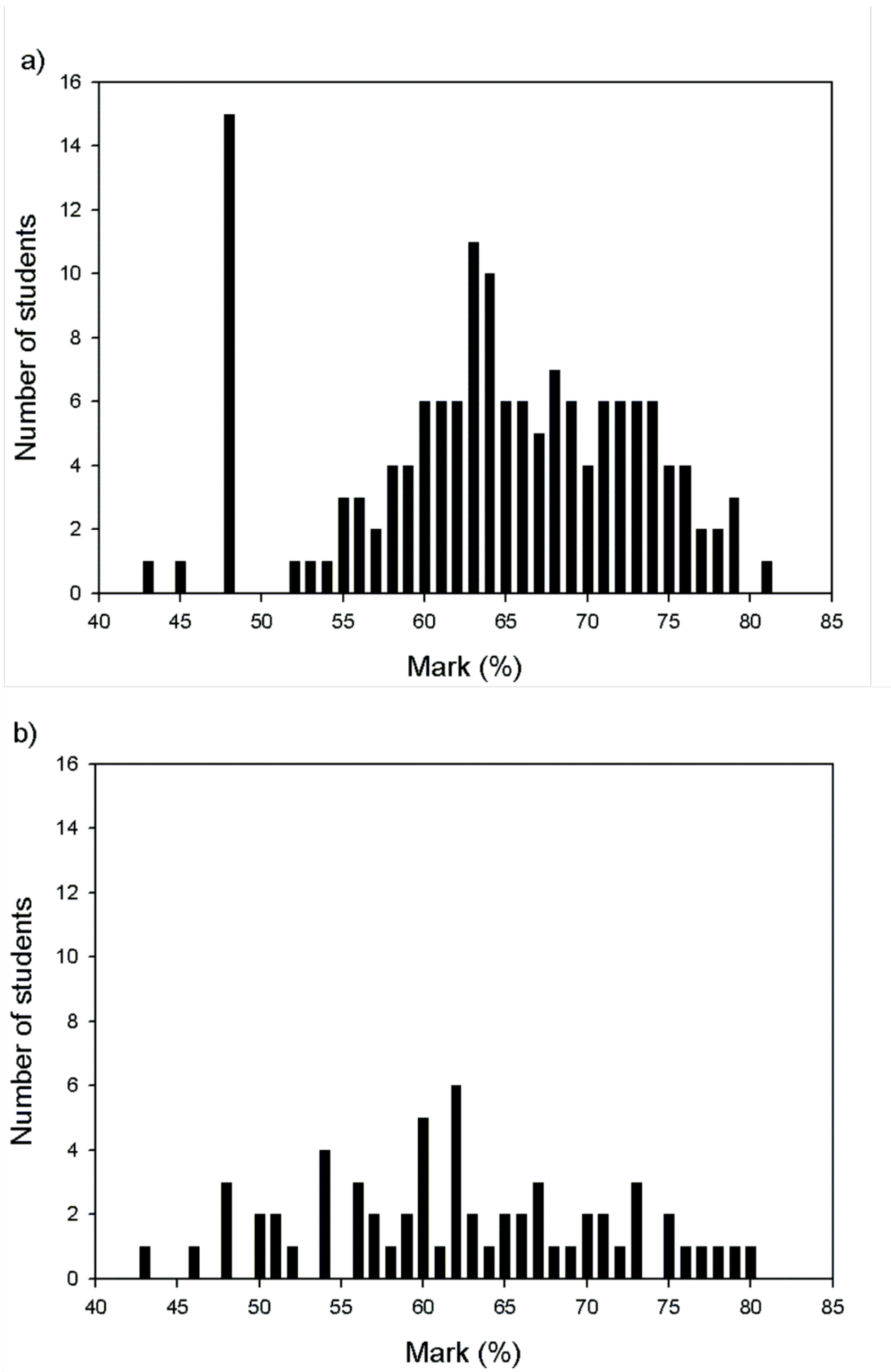
After two years, the course was reduced to an eight credit course to satisfy other disciplines and faculty. In 2008, the management of the SBCS decided to change the course to a reading and writing course to focus primarily on developing scientific literacy using tutorials only. This was despite objections from staff who felt inquiry- and research-based tutorials and laboratory sessions could develop scientific literacy as well as encourage student participation and interest. The changes to the course over the period 2005-2008 illustrate how an institution's policies and practices can affect course implementation.

Infusing Active Learning

Despite some negativity and wariness, many students responded positively to the change in the course. From the comments and the quality of research reports through the semester, it was clear that student engagement and ownership had increased in most sections of the module. Students had begun to develop

Figure 1

Final Course Marks of Students in the "Hot Topics in Biology" Courses at the UKZN in 2005 before Supplementary Examinations Where a) is the HC and b) is the PMB Campus



the skills necessary to function as scientists, the same skills as listed in the course outcomes. In particular, they had developed scientific literacy, a proficiency that could then be developed further in subsequent years.

One of the perceived problems of the course was the number of assessment tasks in the module. We felt that this was necessary to force students to engage with the module, as we found attendance and completion of tasks was linked to assessment marks. This indicated that this approach has to be maintained until students' perceptions and involvement in the course change from being primarily assessment driven. Similarly, others have identified problems of absenteeism and the degree of work completion linked to graded assessment (Case & Gunstone, 2003; Hockings, 2005). One could reduce the amount of assessment and allow those students who do not take responsibility to perform poorly. However, these same students will be the loudest in condemning the course and its teaching practices. As assessment has a great influence on what, how, and how much students study, Chevins (2005) has shown that lectures replaced by prescribed reading with frequent assessment enhanced students' performance. This is what we were hoping to achieve by replacing lectures with tutorials that demanded reading and discussion by the students.

Are They Learning?

A principal feature of enhancing the ways that university lecturers teach relates to the way knowledge is understood (Dall'Alba, 2005). The understanding of knowledge as absolute and foundational has been challenged with evidence of the pluralization of knowledge within a range of contexts (Dall'Alba, 2005). This then questions the traditional views of knowledge transfer and acquisition, as well as assessment practices (Dall'Alba, 2005). Conversely, with active teaching and learning there is often a focus on skills development rather than on content knowledge. However, reducing teaching to a set of skills or competencies, rather than a holistic learning experience, is as questionable.

There are numerous studies that show that even for large classes, teaching approaches that center on active, inquiry-based, collaborative learning are more effective in promoting student interest, understanding, attitude to learning, and performance than the traditional approaches (Haak, HilleRisLambers, Pitre, & Freeman, 2011; Howard & Miskowski, 2005; Wood & Gentile, 2003). Adoption of some these teaching methods may be interpreted as teaching in a research context (Holbrook & Devonshire, 2005; Weaver et al., 2008; Wood & Gentile, 2003), and generally students respond positively to this (Lindsay, Breen, & Jenkins, 2002). This approach can be described as giving students a sense of how science is performed, rather than what is currently known (Howard & Miskowski, 2005). Revision or transformation of courses to allow student involvement in experimental design, data collection and analysis, and discussion of results in a broader context requires increased laboratory experience to facilitate this inquiry-based learning (Howard & Miskowski, 2005; Weaver et al., 2008). Furthermore, there needs to be a progression from more instructor-guided to a more open-ended student-focused investigation (Howard & Miskowski, 2005). However, it is too much to expect students to do wholly independent research, especially at the first-year level (Wood, 2003). Given the diversity of students, there must also not be an expectation that one can develop all students into researchers. The aim should rather be to instill an inquiry-based attitude through the curriculum (Wood, 2003). Students responded positively to the research-based practicals in our course, especially those that included fieldwork.

There is a perceived but mistaken notion about what content must be covered by an undergraduate biology course (Wright & Klymkowsky, 2005). Furthermore, experience shows that increased in-class discussions, group problem-solving, or any activities that reduce time available for content dissemination provide a more valuable and meaningful learning experience for students (Wright & Klymkowsky, 2005). In particular, students develop content mastery through inquiry-based learning as they try to solve, evaluate, and organize information about relevant problems (Wright & Klymkowsky, 2005). The development of biology-literate students—those who can ask and answer their own biology-relevant questions—should be the goal of undergraduate biology classes. Unfortunately, most undergraduate biology classes fail to achieve this as they are content focused (Wright & Klymkowsky, 2005).

Another important factor to consider in an interactive teaching approach in which students share their opinions is that in addition to this sharing, they actually learn the greater context. This requires them often to modify their opinions, especially if they harbor misconceptions. This is when that real learning occurs.

Improvements in the Teaching and Learning Context

There is a broad array of literature that supports and encourages changes in teaching practices and provides strategies for changes in teaching practice that improve student learning outcomes and their experiences of learning (Allen & Tanner, 2005; Armbruster et al., 2009; Dall'Alba, 2005; Fernandez-Santander, 2008; Preszler, 2009; Weaver et al., 2008). The implementation of the "Hot Topics in Biology" course has challenged staff involved to transform their ways of teaching first year students. When changes in teaching methods occur that are perceived as undermining the familiar, customary ways, there is often resistance or defensiveness by both staff and students (Allen & Tanner, 2005; Dall'Alba, 2005; Knight & Wood, 2005). The latter are often reluctant to become active in the learning process as it requires more effort initially (Dall'Alba, 2005). Dealing with resistance or defensiveness requires a shift to openness and support (Dall'Alba, 2005). Furthermore, the unpopularity among students of changes in teaching methods needs to be downplayed if the actual learning outcomes, opportunities, and motivations are achieved.

Within the context of teaching for active learning, delivery methods need to be evaluated for their effectiveness in achieving learning. There is suggestion that laboratory or studio methods involving team work, hands-on exercises, and minimal lecturing achieve more learning than an interactive lecture approach with questions (Roy, 2003). Our approach on the PMB campus of using the laboratories for tutorials/workshops, where the students were divided into smaller groups (12-15 students) with an assigned a postgraduate facilitator, worked better than the HC campus where initially students were in much larger groups (e.g., 60 students). The former approach allowed more rapid assessment of tasks by the facilitator as well as quicker and more pertinent feedback. We also found that students positively engaged in the field trips and hands-on practicals where they had to collect data and produce a scientific report. Many colleagues were astonished that first-year students had read— albeit slowly—and discussed research papers. Tutorials which were scaffolded with questions that dealt with various issues that contributed to the students' overall understanding of a problem were more successful than those where students had to address the overall problem on their own.

Students' conceptual understanding can be assessed with a variety of tools from portfolios to essays. We used a variety of strategies or a smorgasbord approach, with a range of measures as part of the formative assessment and the examinations as the summative assessment. We found that students' performance improved in most of these over the semester, thus emphasizing the need for a developmental and scaffolding approach to tasks, particularly in the early stages. A mixture of data response and problem-solving questions together with an essay in the final examinations assessed these as well as their mastery of content. There was a range in students' performances that reflected the diversity of abilities and their development. However, the external examiner felt students at the upper end were sometimes assessed too harshly. As Wright & Klymkowsky (2005) assert, the most difficult part in transforming a course to an interactive one is how to pose good questions and how to award grades. Often this requires moving away from select-response or selected/short answer questions that are often the major assessment tools used to assign grades in large enrollment undergraduate courses (Wright & Klymkowsky, 2005). Interestingly, it has been shown that students' content mastery is often better in an interactive course with a problem-solving approach than in traditional courses (Armbruster et al., 2009; Knight & Wood 2005; Wright & Klymkowsky, 2005). Furthermore, areas of student difficulty at the introductory level often persist to higher levels (Dancy & Beichner, 2002), and if the assessment tasks and types at this level do not identify where these difficulties lie, then these problems cannot be addressed.

Students' Perceptions

Student feedback can be enlightening, but its worth is limited (Dancy & Beichner, 2002). In addition, as most students are familiar with a direct lecture mode format, the demands of an interactive course may take them out of their comfort zone and so cause them to respond negatively in an evaluation (Dall'Alba, 2005; Knight & Wood, 2005). If education is to be student-centered, then students need to be consulted. Generally students have positive views of student-centered learning, but they show concern about whether the resources to implement this approach are adequate (Lea, Stephenson, & Troy, 2003). The PMB students were generally positive, and it will be interesting to follow their perception of the course as they move through their subsequent years of study.

Lessons Learned

We found that lecturers were more accepting of the change towards active learning when they were more involved in the course development. Although we established that there was still a place for lectures, we found that they could be reduced in number to allow for more interactive and hands-on tutorials and practicals which encouraged the development of science process skills in learners. Our results and observations indicate that smaller class sizes and enjoyment of the course material will generally result in better student interaction, greater participation, and, consequently, higher class marks and a better pass rate. We also found that the use of facilitators greatly benefitted the students in numerous ways, such as providing feedback, encouraging class discussions, acting as mentors, and developing students' confidence. Despite some initial resistance, many students responded positively to the change in the course, and our more hands-on and interactive approach generally improved students' learning, attitude, and performance.

Conclusions

Despite problems in showing some students and staff that the approach used in this biology first year course produced more meaningful learning, most of those involved in the course felt it contributed to the overall outcomes required of students. Other first-year course instructors need to be encouraged to change to a more interactive mode of teaching and learning. The attempt to encourage a change in teaching and learning methods, as reported here, only represents change in one course within a discipline, rather than across all undergraduate courses, or across the biology curriculum at the UKZN. It needs to be adopted at these other levels. The benefits of reform could be far reaching with a domino effect on cognitive gains, real-world applications, and acquisition of skills, with science as the greatest beneficiary.

References

Alghasham, A. A. (2012). Effect of learners' learning styles on classroom performance in problem-based learning. *Medical Teacher, 34,* S14-S19. doi:10.3109/0142159X.2012.656744

Allen, D., & Tanner, K. (2005). Infusing active learning into the large-enrollment biology class: Seven strategies, from the simple to complex. *Cell Biology Education, 4*, 262-268. doi:10.1187/cbe.05-08-0113

American Association for the Advancement of Science. (2009). *Vision and change in undergraduate biology education: A call to action*. Washington, DC: American Association for the Advancement of Science.

Andrews, T. M., Leonard, M. J., Colgrove, C. A., & Kalinowski, S. T. (2011). Active learning not associated with student learning in a random sample of college biology courses. *CBE Life Sciences Education, 10,* 394-405. doi:10.1187/cbe.11-D7-D061

Armbruster, P., Patel, M., Johnson, E., & Weiss, M. (2009). Active learning and student-centred pedagogy improve student attitudes and performance in introductory biology. *CBE Life Sciences Education, 8*, 203-213. doi:10.1187/cbe.09-03-0025

Brenner, K. (2003). Fueling education reform: Bio2010-biology for the future. *Cell Biology Education, 2*, 85-86. doi:10.1187/cbe.02-11-0053

Case, J., & Gunstone, R. F. (2003). Going deeper than deep and surface learning approaches: A study of students' perceptions of time. *Teaching in Higher Education, 8*(1), 55-69.

Chevins, P. F. D. (2005). Lectures replaced by prescribed reading with frequent assessment: Enhanced student performance in animal physiology. *Bioscience Education Electronic Journal, 5*(1), 1-12.

Dall'Alba, G. (2005). Improving teaching: Enhancing ways of being university teachers. *Higher Education Research and Development, 24*, 361-372. doi:10.1080/07294360500284771

Dancy, M. H., & Beichner, R. J. (2002). But are they learning? Getting started in classroom evaluation. *Cell Biology Education, 1*, 87-94. doi:10.1187/cbe.02-04-0010

Exeter, D. J., Ameratunga, S., Ratima, M., Morton, S., Dickson, M., Hsu, D., & Jackson, R. (2010). Student engagement in very large classes: The teachers' perspective. *Studies in Higher Education, 35,* 761-775. doi:10.1080/03075070903545058

Fernandez-Santander, A. (2008). Cooperative learning combined with short periods of lecturing. *Biochemistry and Molecular Biology Education, 36*, 34-38. doi:10.1002/bmb.20141

Freeman, S., Haak, D., & Wenderoth, M.P. (2011). Increased course structure improves performance in introductory biology. *CBE Life Sciences Education, 10*, 175-186. doi:10.1187/cbe.10-08-0105

Goldfinch, J., & Hughes M. (2007). Skills, learning styles, and success of first-year undergraduates. *Active Learning in Higher Education, 8*, 259-273. doi:10.1177/1469787407081881

Haak, D. C., HilleRisLambers, J., Pitre, E., & Freeman, S. (2011). Increased structure and active learning reduce the achievement gap in introductory biology. *Science, 332*, 1213-1216. doi:10.1126/science.1204820

Handelsman, J., Ebert-May, D., Beichner, R., Bruns, P., Chang, A., Dehaan, R., Gentile, J., Lauffer, S., Stewart, J., Tilghman, S. M., & Wood, W. B. (2004). Scientific teaching. *Science, 304*(5670), 521-522.

Hockings, C. (2005). Removing the barriers? A study of the conditions affecting teaching innovation. *Teaching in Higher Education, 10*, 313-326. doi:10.1080/13562510500122149

Holbrook, N. J., & Devonshire, E. (2005). Simulating scientific thinking online: An example of research-led teaching. *Higher Education Research and Development, 24*, 201-213. doi:10.1080/07294360500153844

Howard, D. R., & Miskowski, J. A. (2005). Using a module-based laboratory to incorporate inquiry into a large cell biology course. *Cell Biology Education, 4*, 249-260. doi:10.1187/cbe.04-09-0052

Jones, S. E. (2007). Reflections on the lecture: Outmoded medium or instrument of inspiration? *Journal of Further and Higher Education, 31*, 397-406. doi:10.1080/03098770701656816

Klymkowsky, M. W., Garvin-Doxas, K., & Zeilik, M. (2003). Bioliteracy and teaching efficacy: What

biologists can learn from physicists? *Cell Biology Education, 2*, 155-161. doi:10.1187/cbe.03-03-0014
Knight, J. K., & Wood, W. B. (2005). Teaching more by lecturing less. *Cell Biology Education, 4*, 298-310. doi:10.1187/05-06-0082
Kumar, A. (2005). Teaching systems biology: An active learning approach. *Cell Biology Education, 4*, 323-329. doi:10.1187/cbe.04-12-0057
Lea, S. J., Stephenson, D., & Troy, J. (2003). Higher education students' attitudes to student-centered learning: Beyond "educational bulimia"? *Studies in Higher Education, 28*, 321-334. doi:10.1080/03075070309293
Lindsay, R., Breen, R., & Jenkins, A. (2002). Academic research and teaching quality: The views of undergraduate and postgraduate students. *Studies in Higher Education, 27*, 309-327. doi:10.1080/03075070220000699
Meltzer, D. E., & Manivannan, K. (2002). Transforming the lecture-hall environment: The fully interactive physics lecture. *American Journal of Physics, 70*, 639-654. doi:10.1119/1.1463739
Miller, J. E., & Cheetham, R. D. (1990). Teaching freshmen to think-active learning in introductory biology. *Bioscience, 40*, 388-391. doi:10.2307/1311217
Preszler, R. W. (2009). Replacing lecture with peer-led workshops improves students learning. *CBE Life Sciences Education, 8*, 182-192. doi:10.1187/cbe.09-01-0002
Roy, H. (2003). Studio vs interactive lecture demonstration-effects on student learning. *Bioscience, 29*(1), 3-6.
Rust, C. (2002). The impact of assessment on student learning: How can the research literature practically help to inform the development of departmental assessment strategies and learner-centred assessment practices? *Active Learning in Higher Education, 3*, 145-158. doi:10.1177/1469787402003002004
Thornton, R. K., & Sokoloff, D. R. (1998). Assessing student learning of Newton's laws: The force and motion conceptual evaluation and the evaluation of active learning laboratory and lecture curricula. *American Journal of Physics, 66*, 338-352. doi:10.1119/1.18863
Ueckert, C., Adams, A., & Lock, J. (2011). Redesigning a large-enrolment introductory Biology course. *CBE Life Sciences Education, 10*, 164-174. doi:10.1187/cbe.10-10-0129
Wass, R., Harland, T., & Mercer, A. (2011). Scaffolding critical thinking in the zone of proximal development. *Higher Education Research & Development, 30,* 317-328. doi:10.1080/07294360.2010.489237
Weaver, G. C., Russell, C. B., & Wink, D. J. (2008). Inquiry-based and research-based laboratory pedagogies in undergraduate science. *Nature Chemical Biology, 4*, 577-580. doi:10.1038/nchembio1008-577
Wood, W. B. (2003). Inquiry-based undergraduate teaching in the life sciences at large research universities: A perspective on the Boyer Commission Report. *Cell Biology Education, 2*, 112-116. doi:10.1187/cbe.03-02-0004
Wood, W. B., & Gentile, J. M. (2003). Teaching in a research context. *Science, 28*, 1510. doi:10.1126/science.1091803
Wright, R. L., & Klymkowsky, M. W. (2005). Points of view: content vs process: Is this a fair choice? Undergraduate biology courses for nonscientists: Toward a lived curriculum. *Cell Biology Education, 4*, 189-196. doi:10.1187/cbe.05-04-0073

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Appendix A
Details of Lectures/Tutorials: Knowledge and Skill Development in the "Hot Topics in Biology" First-Year Biology Course (PMB campus, 2005-2006)

		Lectures		Tutorial in Laboratory (2 periods)			Tests/Essay
Week	Theme	1	2	Task 1	Task 2	Skills	
1	Biological warfare-human immunity	Introduction to course	Pathogens and fighting back	Characteristics of blood-types and origins of leucocytes	Lines of defence-surface barriers	Interpreting diagrams-how the body fights back	
2		Lines of defense-non-specific and specific responses	Lines of defense-specific responses	Lines of defense-specific responses	Defenses enhanced, misdirected or compromised-Immunization, allergies, stress	Essay skills and Discussion	
3		Defenses enhanced, misdirected or compromised-autoimmune disorders, deficient immune responses	Medic to speak on AIDS and Antiretrovirals	AIDS-immune system compromised		Interpreting diagrams-how the body fights back. Discussion	
4	Biological weapons-Muthi plants	Introduction - taxonomy, compounds	Important plants and their chemicals	Important plants and their chemicals		Using dichotomous keys, classification, Discussion	Hand in essay
5		Research-detection, propagation	Research-detection, propagation	Economics	Economics	Supply and demand-Muthi trade-discussion of paper, numeracy	Test
6		Research-detection, propagation	Herbalist to speak	Ethics	Legalizing dagga debate	Discussion, research, debate	
7	Time Bomb-Defense of the earth	Climate change	Climate change	Climate change-Carbon cycle	Climate change-Carbon cycle	Interpreting diagrams- carbon Cycle. Discussion. Synthesis.	
8		Climate change	Climate change	Climate change	Climate change	Interpreting diagrams and numeracy. Discussion. Interpretation	
9		Climate change	Climate change	Climate change	Climate change	Interpreting diagrams and numeracy. Discussion. Interpretation	
10	Alien Invasion	What are plant and animal aliens, and why are they successful?	Continued	Arrival of aliens-history	Effects of aliens	What are aliens-comprehension tasks	
11		Need for concern-conservation of biodiversity	Research-pollination and dispersal	Research-pollination and dispersal	Research-biological control	Why are aliens successful- numeracy and comprehension tasks discussion of paper	Test
12		Research-biological control	Research-biological control	Research-biological control-case study	Research-biological control-case studies	Interpretation of diagrams-discussion of research papers	
13		Biological control	Biological control	Biological control	Biological control- case studies	Discussion of research papers	

Appendix B
Details of Practicals: Skill and Knowledge Development in the "Hot Topics in Biology" First Year Biology Course (PMB campus, 2005-2006)

Theme	Biological Warfare-Human Immunity		
Practical	1	2	3
Title	Pathogens and defense	HIV Transmission Rates	Condom Quality
Introduction	Pathogens, leucocytes	Transmission rates	Introduction
Task 1	Size and description of viruses plus questions	Hypothesis	Hypothesis
Task 2	Size and description of bacteria, plus questions	Collection of data on transmission rates using whole class with beakers and pipettes	Collection of data on transmission rates using whole class with beakers and pipettes
Task 3	Importance of leucocytes: use of microscope, drawing, scale, annotation	Tabulate results	Tabulate results
Task 4	Origin of leucocytes-examination of thymus and bone in dissected rat	Graph	Graph
Task 5	Analogy of warfare	Discussion and conclusion	Discussion and conclusion
Skills developed	Observation, interpretation, scale, drawing, 3D, synthesis	Use of scientific method, hypothesis testing, numeracy, data collection, analyzing results, tabulation, graphs, synthesis	Use of scientific method, hypothesis testing, numeracy, data collection, analyzing results, tabulation, graphs, synthesis
Theme	Biological Weapons-Muthi Plants		
Practical	4	5	6
Title	Muthi plants	Extraction techniques 1	Field trip to Muthi market
Introduction	Introduction: importance	Introduction	
Task 1	Identifying important muthi plants-Use of dichotomous key to identify	Hypothesis	
Task 2	Drawing	Collection of data	
Task 3	Tabulate similarities and differences	Tabulate results	
Task 4	Interpretation of data on removal-questions Interpretation of data on economics-questions	Graph	
Task 5	Discussion and conclusion	Discussion and conclusion	
Skills developed	Observation, use of dichotomous keys, classification, interpretation, scale, drawing, 3D, numeracy, tabulation, synthesis	Use of scientific method, hypothesis testing, numeracy, data collection, analyzing results, descriptive statistics, tabulation, graphs, synthesis	
Theme	Biological Weapons- Muthi Plants		
Practical	7	8	9
Title	Field trip to weather station: Cedara	Climate change	Climate change
Introduction	Introduction: Weather	Introduction	Introduction
Task 1	Temperature	Data analysis and interpretation	Video
Task 2	Rainfall	Data analysis and interpretation	Video
Task 3	Wind	Data analysis and interpretation	
Task 4	Evaporation	Data analysis and interpretation	
Task 5	Data analysis and interpretation		
Skills developed		Numeracy, data collection, analyzing results, descriptive statistics, tabulation, synthesis	Observation and thinking

Practical	10	11	12
Title	Urban aliens-Field trip to collect data	Rural aliens-Field trip to collect data	What are aliens?
Introduction	Introduction: cont.	Introduction: Extent of alien invasives	Introduction: aliens
Task 1	Hypothesis	Hypothesis	Identifying important alien plants-Use of dichotomous key to identify
Task 2	Synthesis of data	Data collection: Microhabitat, alien identification and density estimation	Tabulate similarities and differences
Task 3	Tabulate results	Tabulate results	Interpretation of data on removal-questions
Task 4	Discussion and conclusion		Interpretation of data on economics-questions
Task 5			Discussion and conclusion
Skills developed	Use of scientific method, hypothesis testing, numeracy, data collection, analyzing results, descriptive statistics, tabulation, graphs, synthesis	Use of scientific method, hypothesis testing, numeracy, data collection, analyzing results, descriptive statistics, tabulation, synthesis	Observation, interpretation, use of dichotomous keys, classification, scale, drawing, 3D, numeracy, tabulation, synthesis

Appendix C
Results of Hot Topics in Biology Students' Evaluation (PMB Campus, 2005)

Biology 104 Evaluation 2005
This is an anonymous questionnaire. Please express yourself freely. Your honest feedback will help us improve the Biology 104 course. Thank you for your effort and time.
For questions 1- 12, your possible answers are:
A = strongly disagree B = disagree C = neither agree nor disagree D = agree E = strongly agree

Respondents=49	Responses shown as %				
General Aspects of the course	A	B	C	D	E
1. A detailed course syllabus and information on course requirements and assignments was provided at the beginning of the course.	4.2	8.3	16.7	47.9	22.9
2. The different components of the course were all relevant.	2.1	16.7	18.8	43.8	18.8
3. Lecturers were generally available.	2.0	6.1	12.2	49.0	30.6
4. I thought this course was well organized.	4.1	16.3	10.2	47.0	22.5
5. This course is appropriate to my major/program.	8.2	6.1	30.6	32.7	22.5
6. I feel that I have developed intellectually beyond the point I was at when I started the course.	2.1	6.3	12.5	41.7	37.5
7. In Biology 104 I have learned general skills like reading, thinking, analysis and interpretation of data. I have been able to use these skills in other courses.	2.0	0.0	12.2	49.0	36.7
8. I find the language in the notes easy to understand.	0.00	10.64	19.15	55.32	14.89
9. I am able to link up the different units studied throughout the year to get a good understanding of Biology 104.	2.1	8.3	33.3	52.1	4.7
10. I learned something of value in the course.	4.3	0.0	4.3	57.5	34.4
11. The Biology 104 course has helped me to put more emphasis on understanding than on learning something off by heart.	2.0	6.1	16.3	55.1	20.4
12. The tutorials helped me to think further and learn more about the topic than was in the notes.	2.1	8.3	22.9	41.7	25.0
Relative to other courses you have taken:	Much Higher	Average	Much Less		
13. The intellectual challenge presented was:	37.5	56.3	6.2		
14. The amount of effort you put into this course was:	37.5	56.3	6.2		
15. The amount of effort to succeed in the course was:	37.5	56.3	6.2		
	No	Unsure	Yes		
16. Was this course intellectually stimulating? Did it stretch your thinking?	0	12.5	87.5		
17. Will you recommend this course to other students?	4.2	12.5	83.3		

1. What ONE thing has contributed to your enjoyment of each section of the course?	
Immune system	talk by guest speaker (6), AIDS (7), how immune system works (11), practicals (8), lecturer (3)
Medicinal plants	field trips, esp. muthi market (14), usefulness of plants (8), cultural side (4)
Climate Change	field trips, esp. weather station (5), lecturer and lectures (5), esp. global warming and el Nino/la Nina and how it affects real life (12)
Alien Invasives	everything (13), lecturer and lectures (6), field trips and practicals (8), biological control (6)
2. What ONE thing have you least enjoyed of each section of the course:	
Immune system	AIDS (6), rote learning (3)
Medicinal plants	lecturer/lectures (5), learning names (3)
Climate Change	lecturer/lectures (8), hard to understand (5), tutorials and practicals (8)
Alien Invasives	amount of reading (3)
3. What ONE suggestion would you make to improve the course?	
	demonstrators: same marking and increase number, don't like tutorials since long as practical,
	need better notes
4. Any General Comments:	
	good course, there are issues with demonstrators, make tutorials easier