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Course Redesign: An Evidence-Based Approach

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Course Redesign: An Evidence-Based Approach

Abstract

A first year non-majors biology course, with an enrollment of around 440 students, has been redesigned from a course of traditional content and teaching style to one that emphasizes biological concepts in current global issues and incorporates active learning strategies. We were informed by the education literature incorporating many aspects of established curriculum redesign principles and extended its application to a biology course. Systematic measurement of student attitudes and collection of student feedback through a series of surveys as well as focus group interviews proved to be invaluable in the course redesign process. The information gathered over a two-year period enabled us to fine-tune the course content and teaching strategies effectively to better meet the interests of students in the non-majors course as was documented by the evidence gathered in this research.

Un cours de biologie de première année pour étudiants qui ne se spécialisent pas dans ce domaine, dans lequel étaient inscrits 440 étudiants, a été remanié. Ce cours, dont le contenu et le style d'enseignement étaient traditionnels, est devenu un cours où les concepts de biologie ont été mis en valeur dans le contexte des questions globales d'actualité, et des stratégies d'apprentissage actif y ont été incorporées. Nous avons puisé nos ressources dans les publications consacrées à l'éducation qui incorporent les principes établis de remaniement des programmes de cours et nous avons appliqué ces principes à un cours de biologie. La mesure systématique des attitudes des étudiants, les commentaires recueillis auprès des étudiants par le biais de plusieurs sondages, ainsi que les entrevues de groupes témoins, se sont avérés inestimables au cours du processus de remaniement du cours. Les renseignements recueillis pendant une période de deux ans nous ont permi d'affiner de façon efficace le contenu du cours ainsi que les stratégies d'enseignement afin de mieux répondre aux intérêts des étudiants dans des cours qui ne s'adressent pas à des spécialistes du sujet enseigné, tel que documenté par l'évidence recueillie au cours de cette recherche.

Keywords

undergraduate, non-majors, biology, course redesign, attitudes

Cover Page Footnote

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The goal of science education has shifted from focusing only on content to including teaching how to think critically about scientific information and making sound decisions as citizens (American Association for the Advancement of Science, 2010; Boyer Commission, 1998; Woodin, Smith & Allen, 2009). The breadth of content knowledge in biology is vast and constantly expanding. Introductory undergraduate biology courses often include an overview of topics without sufficient time to explore them in depth, hence providing only a cursory introduction to foundational concepts. If one of our teaching goals is for students to think critically about biological issues, we need to guide them in building conceptual frameworks, allowing them to assess the validity of new information they encounter and continue to build their base of biological knowledge.

Research in science education has provided clear evidence that student engagement can be enhanced by using active learning strategies (Allen & Tanner, 2005; Otero & Gray, 2008). First, course concepts need to be made explicitly relevant to students, enhancing their engagement and motivating them to internalize the course material. Second, in addition to information transfer, discussions, exercises or activities need to be incorporated to promote student engagement. Therefore, review and redesign of existing undergraduate biology courses are necessary to accomplish the educational goals of enhancing student engagement and including critical thinking skills (e.g., Handelsman et al., 2004; Howard Hughes Medical Institute, 2002; National Research Council, 2003; Wood, 2009; Woodin, Smith & Allen, 2009).

What Are the Elements of Effective Course Redesign?

The course redesign process is well-documented in the literature, and is often described as a series of stages or steps (forward or backward) or a cycle of revision (Allen & Tanner, 2007; Diamond, 1989; Fink, 2003; Wiggins & McTighe, 1998; Wiles & Bondi, 1984). Wiles & Bondi (1984) describe a four step cycle where the steps involved analyzing the educational context, designing the new curriculum, implementing the changes and evaluation of the redesign. Diamond (1989) describes a more general curriculum development process having two phases that consist of project selection and design, production, implementation and evaluation. More recently, Allen & Tanner (2007) outlined a three phase model of curriculum development that incorporates a "backwards design" process originally developed by Wiggins & McTighe (1998). In the backward design, one first identifies the desired results, followed by determining acceptable evidence and planning for the appropriate learning experiences and forms of instruction (Wiggins & McTighte 1998). Although the various curriculum design models differ in their emphasis of specific elements and in their grouping of processes and order of consideration, the common elements of these models consist of: (a) gathering of information, (b) reinvention of the curriculum, (c) implementation, and (d) evaluation of the effectiveness of the revisions.

How Can We Measure the Effectiveness of a Redesigned Course?

To determine the effectiveness of a redesigned course, many studies have compared learning gains and changes in student attitudes towards science (Armbruster, Patel, Johnson & Weiss, 2009; Knight & Smith, 2010; Libarkin, 2001). However when the course revision involves a major change in the course content including new learning outcomes and new assessment tools it may not be possible to compare student achievement in the original and the redesigned courses.

Since pre-held beliefs about a discipline are known to play a role in conceptual learning (Perkins, Adams, Pollock, Finkelstein, & Wieman, 2005), an indirect measure to capture the effectiveness of a redesigned course would be to investigate student beliefs and attitudes towards the subject. Student attitudes towards science consist of multiple affective components that can be captured with self-report measures based on feelings (e.g., anxiety, enjoyment), beliefs (e.g., contribution to society, self-esteem), and values (influenced by peer group, family culture) (Osborne, 2003; Russell & Hollander, 1975). Student perceptions and preferences can be gauged in various ways through informal conversations, structured focus group discussions, or surveys (Ramsden, 1998; Russell & Hollander, 1975). Questionnaires have also been used extensively to quantitatively assess student attitudes (Knight & Smith, 2010; Sundberg & Dini, 1993) and document the impact of new teaching strategies (Armbruster, Patel, Johnson, & Weiss, 2009; Libarkin, 2001; Osborne, 2003). Russell & Hollander (1975) and Oliver & Simpson (1988) reported a correlation between positive attitudes and achievement in learning. More recently, surveys have been developed to assess student beliefs towards specific science disciplines such as Physics (i.e., CLASS-Phys (Adams et al., 2006), Chemistry (i.e., CLASS-Chem) (Barbera, Adams, Wieman, & Perkins, 2009), and Biology (i.e., CLASS-Bio) (Semsar, Knight, Birol, & Smith, 2011). These forms of evidence better inform teaching faculty and administrators when making decisions regarding support and adoption of course redesign or new approaches to teaching (Libarkin, 2001).

In this paper, we report on our evidence-based approach in redesigning a traditional lecture-based biology course for first-year students not majoring in the discipline and provide a description of the steps in the redesign process. Our intent was to redesign the course to be relevant to non-majors students whose needs were different than students majoring in biology and to incorporate teaching strategies that would enhance student engagement. To achieve this, we systematically collected student feedback and other data using surveys and focus group sessions to inform our revision process. A survey on student attitudes was also used to document student beliefs towards biology (as pre and posttest) as an indicator of the degree of success in reaching the goals of our course redesign. Student feedback from the first implementation of the redesigned course identified issues that were addressed in the second revision leading to a course that was aligned with the interests of the non-majors students. Since substantial changes were made to the content and teaching methods in the course we could not directly compare student attitudes or learning gains from the original version of the course. This paper documents our course redesign process and describes student perceptions and changes in their attitudes towards learning biology in the revised course.

Methods

Description of the Non-Majors Biology Course

Cellular and Organismal Biology (BIOL 111) is a 3-credit first year non-majors course that has been taught at the University of British Columbia (UBC) for over a decade. It is delivered as three one-hour classes per week in a large lecture hall (maximum enrollment of 226 students/section, two sections in total). Each section was taught by a single instructor with additional help for marking exams. Typically 20% of the students enrolled are physics, computer science or mathematics majors who require a life science credit. Similarly, 33% of the students are from the Faculties of Arts or Education who require a science course credit. This non-majors course has an additional role as a transition course for students with no biology background who want to enter Life Science related programs such as Health Sciences, Forestry, Land and Food Systems, or Human Kinetics. When the constraints of preparing students for further study in biology are imposed, the topics perceived to be appropriate for non-majors are those traditionally taught in grades 11 and 12 of high school biology.

Based on our experience in this course over ten years, we have noticed that many students have the preconception of Biology as an information-laden discipline. Students assume that in order to be successful in a biology course they need to memorize information that is presented in class or in their text books. Those students that have previously avoided biology courses often state that they do not have the capacity for memorization. They do not appreciate that biology is a science where questions are asked, hypotheses are tested, observations are made and data are collected to extend our knowledge. As a result it has been a challenge to persuade students that effective learning of biology requires application of concepts, analysis of evidence and asking critical questions. We believe that shifting student attitudes about biology as a science and their approach towards studying biology are key to reducing resistance to effective learning in this non-majors course. Our redesign of this course was catalyzed in part by the convergence of institutional support for curriculum change, concurrent educational research in the Biology Program exploring student attitudes and beliefs, and instructor dissatisfaction with the inherited traditional curriculum.

We undertook the transformation of the course from one that surveys traditional topics to one that focuses on concepts underlying current biological issues. In a typical non-majors course students are introduced to topics and insights in a discipline other than their chosen “major” course of studies. If there is no intention to take further courses in the non-major discipline, the content of a true non-majors course need not be constrained by concepts required for upper level courses (Klymkowsky, 2005; Knight & Smith, 2010; Sundberg & Dini, 1993; Wright, 2005). The syllabus of a non-majors course should include concepts that students can relate to their personal experiences while also providing a conceptual framework of biological knowledge enabling the critique of biological information they encounter. Ultimately students should be able to make informed assessments of biological issues that are of concern to society. Our intention of assisting students to become biologically literate is similar to other developers of non-majors biology courses (Klymkowsky, 2005; Knight & Smith, 2010; Sundberg & Dini, 1993; Wright, 2005).

The specific goals in the redesign process were to: (a) incorporate topics and learning activities to demonstrate how scientific evidence forms the basis of biological knowledge; (b) engage students in learning biological concepts and guide their formation of conceptual frameworks of biological knowledge; and (c) challenge students to think critically about societal issues that are grounded in biological concepts. A further implicit goal was to shift student beliefs about biology as a science, hence, their attitudes towards learning biology.

Course Redesign Process

In a two-year period, we adapted established models of course curriculum redesign previously described (especially Wiles & Bondi, 1984) that best fit our institutional context. The steps that were essential to transforming this non-majors biology course are illustrated in Figure 1 and are described below.

Identifying the need for change (Step 1). There had been no review of the course curriculum for non-major students for two decades despite significant developments in the field of biology. The traditional methods of instruction in this course had involved lecturing to students and requiring that they reproduce that information in assignments or exams. The course curriculum had been determined by faculty members based on traditional topics found in first year biology text books with little consideration of the interests of students. After teaching the course in this way for several years we could no longer disregard a significant lack of engagement and interest among most students. Student performance and feedback were initial indicators that change was needed. It appeared that a majority of students were expending a moderate amount of effort in the course. Many students were candid in that they were only interested in passing the course and wanted the *minimum requirements* identified. The frustration of teaching students a curriculum with little relevance to their interests led to a reflective process of reviewing the course content and teaching strategies. Concurrently, there was a review of the entire Biology Program and it became evident that this course need not be a ”whirlwind superficial tour” as described by Klymkowsky (2005) but an opportunity to enhance biological literacy. New teaching approaches that increase student engagement reported in the literature (Armbruster, Patel, Johnson, & Weiss, 2009; Allen & Tanner, 2005) further reinforced the need to redesign the course.

Information gathering (Step 2). It is recommended that all stakeholders including students, faculty, curriculum committees, program administrators and possibly alumni, employers, graduate programs, and the community need to be consulted in curriculum changes (Wolf, 2008). These discussions are essential for the development of a composite perspective of the instructional context (Diamond, 1989; Davis, 1993) and to help identify what further data need to be collected (Fink, 2003).

In order to define the institutional context for this course we consulted with faculty teaching other non-majors biology courses as well as the administrative Heads of Departments included within the Biology Program (Botany, Zoology, and Microbiology & Immunology). The discussions were useful not only in developing a better understanding of the role of the first year non-majors course among the parties involved but also to identify administrative and budgetary constraints. Specifically, we needed to identify resources that were available as well as the potential for additional resources necessary for implementation of the redesigned course. Knowing our resource limitations, especially funding for graduate teaching assistants, influenced subsequent decisions regarding the choice of teaching strategies, the incorporation of learning technologies, and the form and frequency of student assessments.

Information on student demographics, their motives for taking the course and potentially relevant topics were obtained in a variety of ways. Demographic information was obtained from students' registration and included the Faculty and Program in which they were registered as well as year of study. Further student-related information was gathered through a welcome survey in the first week of the course identifying student intentions and expectations (see Supplemental Materials (SM I) for questions and responses).

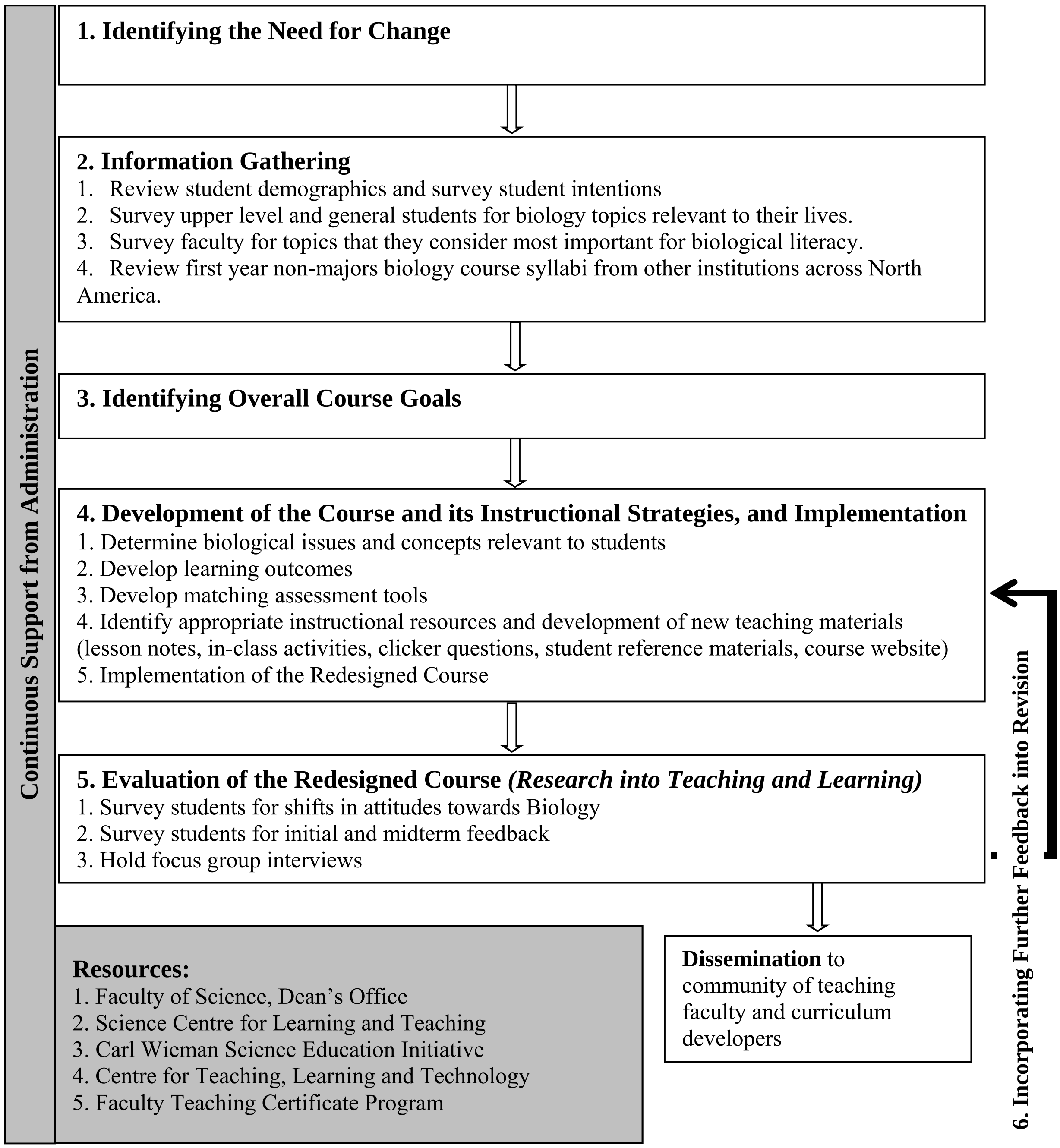

Figure 1. The course redesign process.

Identifying overall course goals (Step 3). Through consultation with faculty and administrators we recognized that the course curriculum needed to guide students to acquire the skills to comprehend the discipline-specific terminology, interpret and apply information, and be able to communicate their reasoning effectively (Klymkowsky, 2005). Therefore, the learning goals of the revised course were transformed from a list of seemingly disconnected traditional topics commonly taught in non-majors courses (Wright, 2005) to a series of biological topics into which we could integrate our broader educational goals (see Table 1).

Table 1
Broad Learning Goals for the Non-Majors Course.*

Before Redesign	− To recognize components of cell structure and understand their integrated metabolic functions. − To understand how plants and animals carry out life functions. − To appreciate the complexity of ecological interactions of organisms with their environment and how the organisms (including humans) modify the world around them.
After Redesign	− To appraise current global issues in relation to biological concepts. − To integrate biological knowledge with their life experiences. − To recognize science as a cumulative, investigative process. − To critically access whether information is scientifically reliable. − To work cooperatively in a team to discuss, debate and problem-solve. − To form biologically sound opinions on societal issues and propose constructive solutions.

*****Adapted from Ohio State University (http://biology.osu.edu/courses/101/)

Development of the course and its instructional strategies, and implementation (Step 4). To determine potential topics that would be of interest to students, a sample group of undergraduate students (n = 24) were surveyed for biology topics that they thought would be relevant and meaningful. In addition, biology faculty (n = 17) were surveyed for biological topics that they felt were important for all citizens to be familiar and appropriate within the scope of a first year non-majors course. Students indicated an interest in more diverse biological topics while faculty had greater agreement on topics that have significant societal impacts (Table 2).

At the same time, the syllabi for first-year non-majors biology courses in other North American institutions were reviewed for novel topics and approaches. We found that non-majors curricula at the first-year level are commonly a survey of majors topics but with less depth or detail (Klymkowsky, 2005; Wright, 2005). In the traditional first year biology course, the list of topics frequently includes cell structure, mitosis/meiosis, plant diversity, animal diversity, and ecology. In the course revision we instead chose topics that the students found interesting and relevant, and through which we could present examples illustrating fundamental biological concepts. For example, we focused on the topic of cancer and embedded the concepts of mitotic cell division and cell cycle.

For each topic included in the new syllabus, a set of student-centred learning outcomes was developed reflecting the change in our approach to teaching this course. The course learning outcomes were designed to challenge students beyond information recall and ranged from lower to higher order cognitive skills as described by Bloom's taxonomy (Bloom, 1956). Students were expected to be able to explain and describe processes as well as apply concepts to new situations and evaluate information. Assessment of student learning through assignments, quizzes and exams were aligned with these learning outcomes. The learning outcomes for the course are provided as Supplemental Material II (SM II).

Table 2
Biology Topics Suggested by Students and Faculty for a Non-majors Biology Course.

Topics	**% faculty**	**% students**
Stem cell research, cloning of animals	0	17
Bioethics of the use of technologies	0	17
Genetic variation and phenotype expressions, e.g., blood types	0	29
Human genome project, DNA mapping, applications of DNA technology	0	29
Human reproductive physiology: hormones, how Viagra works	0	29
Diversity of local flora and fauna, bioregionalism	0	42
Community interactions and habitat conservation	18	13
Effectiveness of antibiotics and drugs, development of super bugs	18	38
Cancer: mechanisms, causes, prevention	18	42
Impact of pollutants, bioaccumulation and biomagnifications	24	13
Role of microbes, friendly bacteria, disease causing bacteria	41	17
Basic Human nutrition and fad diets, organic foods, pros and cons	41	25
Basic epidemiology:spreading of disease, e.g., HIV and AIDS, ANTRAX	41	38
Ecological footprint, sustainable agriculture and forestry	47	0
Genetic engineering, GM foods – issues and controversies	47	25
Processes of evolution, natural selection	53	0
Inheritance patterns and heredity of genetic disorders	53	13
Human impact on climate change and global warming	71	33
Population growth, carrying capacity	76	13

Based on our experience with first-year students we recognized that multiple forms of student assessment are necessary. First-year students require regular feedback on their progress as they adjust to the norms of higher education. Thus, ongoing assessment provides the impetus for self-regulation of student learning strategies and enhances student success at university (Black & William, 1998; Handelsman, Miller & Pfund, 2007; Wiggins & McTighe, 1998). Prior to the course redesign, the final course grade was determined by two midterm exams (15% and 20%) and a final exam (65%). All exams consisted of numerous short scenarios each with a series of questions assessing the comprehension and application of the related concept. After the course redesign, the final course grade was determined by two midterm exams (10% and 20%), a final exam (45%) in addition to a participation mark (25%) which included the reading quizzes, assignments, and in-class activities. The two sections of the redesigned course were closely coordinated in that although the exams were not identical (except for the common final exam) they were equivalent in format and rigor. Resources were made available to hire a graduate student teaching assistant and an undergraduate peer tutor for each class. As part of a team they provided additional timely feedback to students both in and out of class.

The course had traditionally been entirely lectures of content, a method that can be effective in transmitting information and stimulating interest in ideas by a skilled lecturer (Davis, 1993). However, the overwhelming evidence on the effectiveness of active learning in the science education literature inspired us to integrate other teaching strategies into the lecture-based sessions (Allen & Tanner, 2005; Armbruster, Patel, Johnson & Weiss, 2009; Springer, Stanne, & Donovan, 1999). As such, we chose to intersperse instruction with the use of personal response systems (PRS), small group discussions, case study exercises, and hands-on manipulations. These strategies not only promised to enhance student engagement but also provided formative feedback and reinforced concepts. Prior to class, students were required to complete text readings and on-line quizzes with the expectation that they would be better prepared to complete in-class activities and contribute to in-class discussions. During class, student comprehension and engagement were assessed by asking students to respond to multiple choice questions using hand-held PRS or clicker devices. In this way both the students and instructors received immediate feedback, for the students whether they had understood or correctly applied the concept and for the instructor the number of students who had misconceptions. These misconceptions were addressed immediately before moving on to more sophisticated discussions (Caldwell, 2007).

Students formed informal groups of three or four to complete the in-class activities such as manipulating paper chromosomes through the stages of meiosis and tracking the location of alleles to reinforce the topic of creating variation. During these and other class activities students would discuss the processes, answer questions and solve problems requiring the clear use of biological terms. The instructor, graduate student teaching assistant and undergraduate peer tutor circulated among the students and facilitated the group discussions.

In addition, small group work that required gathering of information on a specific topic and the development of consensus of opinion was assigned to be completed primarily outside of class time. Formation of groups for the first two assignments was generated randomly through the course management system, while the students were permitted to form their own groups for the third assignment. The first group assignment required one or two students participating in a field trip during which they captured digital images of native species. As a group they were initially required to identify the species and then prepare a food web indicating the ecological connections among the biota. These small group assignments were important because they emphasized that information needed for understanding biological questions is available outside of the class room and the text. In addition students developed a network of peers with which they could work and study. Participation in each of these activities contributed a small percentage of the students' final grade.

Evaluation of the redesigned course - Year 1 (Step 5). Evaluation of the new course was an integral part of the course redesign process with evidence gathered in both the first (year 1, Fall 2007) and the second (year 2, Fall 2008) offerings of the revised course. In the evaluation

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plan, our intent was to monitor changes in student beliefs towards biology as a science and to capture student impressions of their learning experience. Since the course learning outcomes and content changed significantly with the course redesign it was not appropriate to compare learning gains from previous years. Instead, investigating shifts in student beliefs and attitudes towards biology within the course was identified as a suitable measure of the effectiveness of the redesigned course without intending a comparison with the original course (Libarkin, 2001; Russell & Hollander, 1975).

Students come to university with already established beliefs about biology and how to study the subject. These beliefs shape their attitudes towards learning. By assessing the shifts in student attitudes towards biology over the term we obtained a measure of the effect of the course on student learning. In addition, surveys and focus groups were specifically designed to gauge student perspectives of course structure, including the course content and teaching strategies.

To assist in the implementation of the course evaluation plan a science education specialist (one of the authors) and a graduate student were recruited as part of the research team. Unlike the instructors, they were not directly involved in teaching students and were able to lead the focus group discussions and analyze the data objectively. Other course designers have also found that contributions of the colleagues outside the discipline and instruction from educational literature greatly enhanced the redesign project (Chasteen, Perkins, Beale, Pollock, & Wieman, 2011; McEwen et al., 2009).

Measurement of student attitudes towards biology. In a parallel study a validated attitudinal survey (a.k.a., CLASS-Bio) for measuring student beliefs and attitudes towards biology was developed in collaboration with the University of Colorado, Boulder (Semsar, Knight, Birol & Smith, 2011). The survey consisted of a series of statements requiring responses on a 5-point Likert-scale (ranging from strongly agree to strongly disagree). For a given statement, scoring was categorized as follows: *disagree* if respondents chose strongly disagree or disagree; *neutral* if they chose neutral; and *agree* if they chose agree or strongly agree. Combining the responses this way is consistent with an ordinal characterization of a Likert scale as discussed in detail by Semsar, Knight, Birol, & Smith (2011). Adams et al. (2006) provide a more thorough discussion. Each of the statements in the attitudinal survey had also been validated with experts (n=69 experts representing 30 universities) and we were therefore able to match and compare student responses to the expert responses. Those responses agreeing with the expert (which may not necessarily mean agreeing with the statement) was categorized as “favourable”. Those student responses not agreeing with the expert were categorized as “unfavourable”. The average consensus of expert opinion for all the statements on the final version of CLASS-Bio is found to be 90%.

In administering the survey, we followed an ethics protocol approved by the Behavioural Research Ethics Board (Protocol No. H07-01633) as required by UBC. Participation was voluntary and students received a 0.5% bonus mark for completing each pre and post survey which was administered on-line using the course management system. The surveys were available at the beginning and at the end of the course and stayed open for ten days each time. 41% of the students enrolled in the course completed both pre and post surveys. The data was analyzed using Student’s paired t-test to identify statistically significant changes between pre- and post (p-value of less than or equal to 0.05).

Measurement of student impressions of the teaching strategies and the course curriculum. During week seven of the course a midterm survey was used to obtain student feedback on the effectiveness of the teaching strategies employed, the usefulness of resources and student opinions on the relevance of the new course curriculum (see SM III for survey questions and student responses). This survey was available online, easy to administer and quick to analyze. 67% of students responded to the midterm survey. The feedback was most valuable in identifying elements in the course that needed further modification or that succeeded in supporting student learning.

We also ran two focus groups at the beginning and one focus group at the end of the term that provided insight into student perceptions of course mechanics. Nine students volunteered from one of the sections to participate in the semi-structured, one-hour focus group interviews. These discussions were guided by a set of questions on student opinions on biology as a science, relevance of biology to their lives, attitudes towards learning biology, the topics and mechanics of the course (see SM IV for guiding questions). The sessions were audio-taped, transcribed and coded for emerging themes (see Figure 2). The transcripts were coded by both the authors and the graduate student independently using a standard rubric. Any discrepancies among the coders were discussed and resolved for inter-rater reliability.

Findings

In this section we present the evidence of student perceptions on the redesigned course, elaborate on the results and discuss the implications for the student learning experience.

Emerging Themes

Data from focus group discussions, the welcome, midterm and attitudinal surveys were analyzed separately. It became apparent that common themes were emerging from each set of data. Initial analysis of the focus group dialogues revealed four themes represented in Figure 2: (a) motivation and intentions, (b) attitudes, (c) transitioning to university, and (d) learning experience. When students spoke of why they were taking the course, whether this was due to their interest in studying biology to help them understand the natural world (relevance) or other motives, the responses were categorized as *motivation and intentions*. Student comments revealing perceptions of self-knowledge and responsibility for learning were categorized as *attitudes* along with explanation of their values and beliefs (role of science, humans making a difference, value of biological concepts, application). The third category of *transitioning to university* included student comments on their perspective on course and institution (e.g., role of course, program options, contrast with other higher education institutions, expectations of course/biology, feedback on course) and comparison of high school and university (high school experience, expectations of university learning, class size of labs, tutorials, interactions). The fourth category of *learning experience* includes responses regarding learning strategies (e.g., specific strategies, textbook usefulness, resources or experiences), teaching strategies (emphasis on concepts, building conceptual framework, and usefulness of discussion) and course mechanics (e.g., using media information, assignments requiring critique and analysis, group work, course assessments).

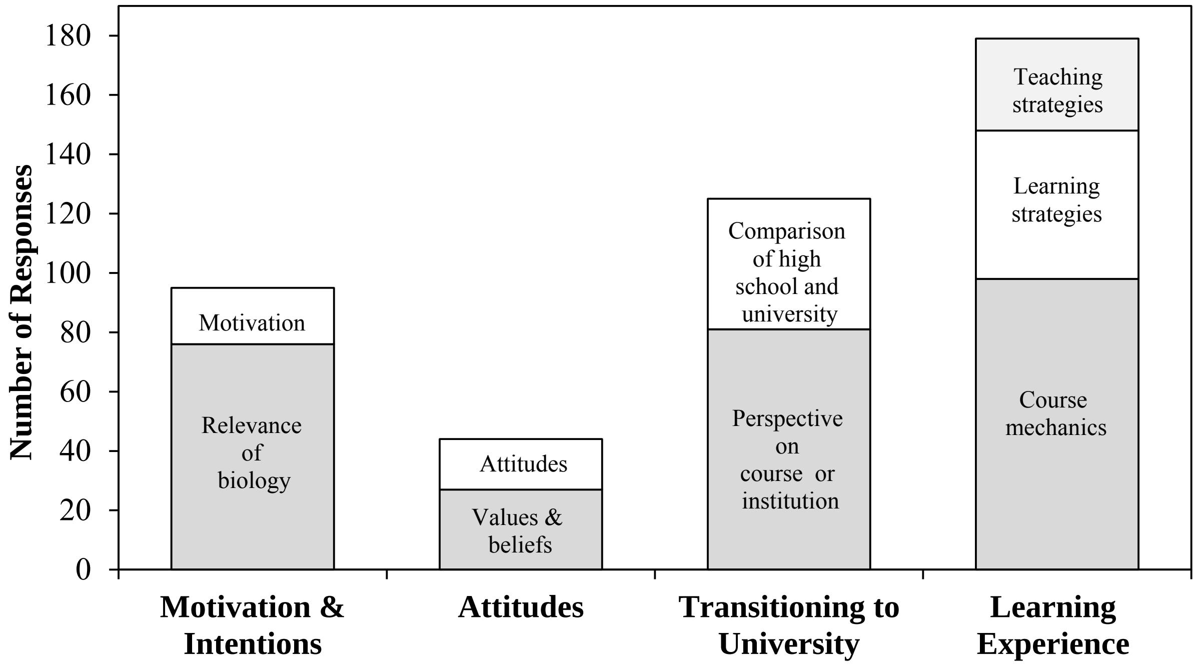

Figure 2. Student responses during focus group discussions grouped into themes.

Student responses regarding *transitioning to university* and *learning experience* were thematically similar and together addressed student learning experiences at university. When the focus group data were considered in conjunction with the data from the welcome, midterm and attitudinal surveys obtained in year 1, three substantive themes persisted: (a) student motivation and intentions, (b) student attitudes, and (c) student learning experiences. The grouping of data into these themes was the most useful for informing further revision of the course for the second year and will be presented below.

Student motivation and intentions. This group of responses included indicators of student backgrounds, their interests in taking this non-majors course, the specific topics that are of particular interest to them, and what they are curious to learn in a biology course. The welcome survey administered in year 1 (See SM I) revealed that almost half of the students were in the Faculty of Science and took the course as a requirement to enter a degree program. 66% of these students were not intending to enter a degree program that required further biology courses. The remaining 34% of the students were considering taking further courses in the Biology Program or one of the affiliated Life Science Programs. This majority of students not intending to continue with biological sciences reaffirmed our assertion that these students would benefit from an emphasis on biological concepts relevant to their lives. The welcome survey revealed student interests in a variety of biological topics: Human physiology and health being the most popular topics, followed by ecological and evolutionary biology, and then human diseases. More than 90% of the students in the midterm survey in year 1 (See SM II) mentioned that they found the topics relevant to their everyday life and interesting either sometimes or more, assuring us that the topics were suitable for this population of students and that we were meeting one of the goals of the course redesign process.

A majority of the students (60%) were in their first year of post-secondary studies and were challenged by the transition to university education needing to adopt suitable learning strategies. Student responses to the attitudinal survey and focus group interviews indicated a decline in their curiosity about biological issues by the end of term which coincided with an increase in stress due to the time constraints to complete remaining course work and prepare for final exams. The majority of students were less willing to explore topics to satisfy curiosity, if the topics were not directly related to material they thought would be examined. Their response to the statement “Given my time constraints, I only study materials that I think will be examined” shifted significantly from 43% to 60% agreement at the end of the term (Table 3).

Table 3
Fall 2007 Attitudinal Survey Responses (Paired) (41% of the Students Participated in Both Pre and Post Survey).

Statements*	**% Favourable**		**p-values**
	Pre	**Post**	
1. I choose to study Biology because I am curious about the living world.	62	42	$p<0.05$
2. Given my time constraints, I only study materials that I think will be examined.	43	60	$p<0.05$
3. Learning Biology changes my ideas about how the natural world works.	79	72	$p<0.05$
4. It is important to study Biology to help find answers to societal problems.	53	71	$p<0.05$
5. It is possible to explain biological ideas with everyday language.	66	57	$p<0.05$
6. I can usually think of several approaches to answering a question in Biology.	35	64	$p<0.05$
7. After I study a topic in biology and feel that I understand it, I have difficulty applying that information to answer questions.	52	55	$p>0.05$
8. If I understand one biological idea, I can only apply that idea to a very similar situation.	34	35	$p>0.05$
9. When I am answering a Biology question, I find it difficult to put what I know into my own words.	40	47	$p>0.05$
10. To understand Biology, I discuss it with friends and other students.	40	40	$p>0.05$
11. For me, biology is primarily about learning known facts as opposed to investigating the unknown.	38	42	$p>0.05$

*Note that in 2007, attitudinal survey was under development. As a result, some of the statements changed in 2008.

Student attitudes. This group of responses included indicators of student beliefs about biology, their abilities and attitudes towards learning it. In the beginning of year 1, almost 79% of the students agreed with the expert-like statement (i.e., 79% favourable) that learning biology would help them to understand the natural world, however this decreased to 72% favorable at the end of the term (see Table 3). Only 53% of the students recognized at the beginning of the course that it was important to study biology to solve societal and environmental problems. These sentiments were evident from both the attitudinal survey and focus group interviews.

Students had not considered that biological concepts could be applied to real life problems. Over the term 71% of all students agreed with the experts in the importance of studying biology to solve societal problems. Furthermore, most of the students interviewed indicated an increased appreciation of the relevance of biology to real world problems. Another belief that shifted significantly over the course of the term was that students came to realize that there was not just one right approach or answer to a biological question (from 35% to 62% favorable). However, there was no significant change in their confidence that they could solve biological problems (from 52% to 55% favorable). Student beliefs about their ability to explain biological concepts with everyday language shifted away from expert-like thinking from 67% to 57% favourable, further indicating a decrease in their confidence in mastering biological concepts.

Shifts in student attitudes towards science have been documented in different sub disciplines. Adams et al. (2006) demonstrated that using the CLASS-Phys survey, changes in teaching practices caused negative shifts in student attitude scores. In chemistry a version of the survey (CLASS-Chem) also documented negative shifts in a first year general chemistry course (Barbera, Adams, Wieman, & Perkins, 2008). Our results are similar to a corresponding report on attitudinal shifts in Biology using CLASS- Bio (Semsar, Knight, Birol, & Smith, 2011).

Student learning experience. This group of responses included indicators of student strategies in learning and studying biology, their approach towards group work, learning activities in the course as well as the course mechanics. In response to the midterm survey (See SM III), almost 80% of the students indicated that they found the learning outcomes useful in guiding their studying while only 10% of the students did not know they existed. During the term, the majority of students (55%) spent 1-3 hours per week on this course. Prior to the midterm exam there was a shift as indicated by students that reported they spent more than 6 hours studying. This clearly indicates that students prioritize their time and effort when preparing for an exam. Krapp (1999) also describes how students modifying their learning strategies changes from elaboration to rehearsal when preparing for an exam.

From the focus group interviews, we learned that when students completed all reading-assignments and quizzes on time, they felt they would be better prepared for the midterm and final exams. Student comments on in-class discussions, the use of PRS to answer questions, in-class activities and group assignments varied greatly. Students seemed to enjoy discussing with neighboring students and using the PRS. As instructors, we noticed an increase in the attention and energy level of the class following the PRS question exercises and found that the most valuable aspect of using the PRS was after the correct answers were revealed and misconceptions were discussed (Caldwell, 2007).

The majority of students who participated in the focus group interviews had reservations about working in groups on assignments, and a few had strong negative aversions to working with other students. The barriers to group work were similar to problems reported by Kamel & Davison (1998). The most profound difficulties were mostly related to time (finding the mutually agreeable time for meetings outside the class), distance and space-related problems (finding a mutually agreeable space for meetings), and behaviour related problems (specifically discussions being dominated by some members of the group). The student experience in group work is reflected in the following comment from student A:

> Even when people show up there, there is always two or three people who know the work who understand what's going on and they kind of do it for everybody else. And the other people are just kind of not paying attention or I don't know they don't care.

In the midterm survey 40% of the students indicated that they would prefer to work individually (see SM III). Some of the students commented that other group members could be difficult to contact, or could not be relied on to meet as arranged or that they did not trust other students to complete their share of the assignments to their standards.

However, there were also other students that provided positive comments regarding group work, indicating that they appreciated the opportunity to interact with students and were sufficiently encouraged to form study groups. This is supported by the midterm survey data which indicated that 54% of the students said that group assignments helped them better understand the concepts (See SM III). The value of discussion in the course came up in the focus groups as represented by the comment: "[Discussion] helps ideas solidify (…) if you could discuss [ideas, then] you remember more."

By the end of the course many students commented that they appreciated the emphasis on understanding concepts rather than memorization of information and that they had become more critical of sources of information. Student B commented, "It's not about the little things like vocabulary and stuff you get. It's more about grasping like ideas and then once you grasp that you can build."

Clearly some students recognized the benefits of the teaching strategies employed, while other students were not convinced of the effectiveness of active learning and discussion. Now that we had identified the barriers to group work and areas of student resistance within this course, we could revise our approach and implement best practices for effective group work (e.g., Handelsman, Miller, & Pfund, 2007; Lord, 1998; Michaelson, Black, & Fink, 1996). We realized that it was most important to promote student buy-in by being explicit about the benefits of specific teaching strategies to their learning (e.g., Felder, 2011).

Incorporating Further Feedback into Revision - Year 2 (Step 6)

The next step in our process of course redesign involved gathering feedback on the new curriculum and identifying issues that needed further consideration and revision (Step 6 in Figure 1). Through the systematic course evaluation process, we realized that various assumptions we had made during the initial redesign phase regarding student attitudes, beliefs and abilities were not always accurate, and we were able to identify issues that needed to be addressed further. The most profound issues are summarized in Table 4. For example, we discovered that we needed to be explicit about the relevance of the biological concepts included in the course because many students did not have the life experience or familiarity with recent events to place the concepts in context. To further elaborate, many students were unaware that many sea foods are prone to accumulation of compounds within organisms and that these compounds were magnified in higher trophic levels. When we consume sea foods, we are part of that chain and will accumulate inorganic compounds such as heavy metals. This concept has ramifications for the health of the human population. The demonstration of the link between biological concepts (e.g., bioaccumulation and magnification) and broader societal or environmental issues was necessary for the students to appreciate the relevance to their own lives. We suspected that the initial lack of interest of students towards the course may have been due in part by the unfamiliarity of the students with the subject. To grab students' attention news items and interesting anecdotes were strategically incorporated into the lessons.

Table 4
A Summary of the Most Profound Curricular Issues Identified in Year 1 and Revisions Implemented in Year 2 Offering of the Course.

Issues Identified in Year 1, Fall 2007	**Revisions Implemented in Year 2, Fall 2008**
The reason for incorporating certain instructional strategies into the curriculum needs to be explained.	Explained the pedagogical benefits of incorporating instructional strategies to student learning to especially alleviate resistance to group work.
The relevance of discipline specific concepts needs to be explicit.	Presented issues students encounter to class as examples of biological concepts
Links to broader societal and global issues need to be demonstrated.	Related concepts to global issues, such as climate change and pollution.
Curricular hooks need to be used to incite interest and provide motivation for learning.	Incorporated current events from news and other media to grab students' attention.
Students need to be motivated to review and study material on a regular basis.	Scheduled a series of assignments and assessment activities throughout the course.
Student confidence in application of concepts through problem-solving need to be promoted.	Incorporated a series of group assignments for students to practice their problem-solving skills.
Students less confident or less sophisticated in their approaches to learning require additional instructional support.	Made supplementary text and web based materials available. Implemented peer tutor program.
Students need to be reassured that assessment in the course will evaluate concepts, critical thinking skills, and problem solving rather than memorization of facts.	Developed assignments and assessment activities that align with learning outcomes and require application of concepts and analysis of information.

We also made modifications to the course structure. We incorrectly assumed that students would appreciate the value of active learning teaching strategies without being explicit about why these techniques were preferable to passively receiving content.

The literature provides mixed reports on the effect of small group activities on student attitudes. Springer, Stanne, and Donnovan (1999) prepared a meta-analysis of small group learning in sciences and conclude that this form of teaching strategy was effective overall. Armstrong, Chang, & Brickman (2007) identified a mix of positive, non-significant, and negative shifts in student attitude following the introduction of curricula intended to increase student engagement. Following a recommendation by Handelsman, Miller, & Pfund (2007), we explained the benefits of discussions and working with peers and noticed a decline in resistance to group activities in year 2 as compared to year 1. It also became evident that many students lacked the appropriate study skills necessary to be successful in the course. By emphasizing the importance of the weekly reading quizzes students would be more motivated to keep up with their studies. Further, to promote students' confidence towards application of concepts we realized that incorporating more activities where students worked on problems was necessary. Not only did students need more practice, they also needed to be assured that assessment in the course would evaluate concepts, critical thinking skills, and solving problems rather than memorization of information. Felder (2011) has more recently advised instructors to persist with active learning strategies as steps can be taken to lessen student resistance.

In year 2 of the course, having implemented the further revisions to address the issues identified in the year 1 pilot, we administered the final version of the attitudinal survey, which is referred to as CLASS-Bio, as well as the welcome and midterm surveys. Student responses to the attitudinal survey are presented in Tables 5 and 6.

Table 5
Attitudinal Survey Responses for Statements with Statistically Significant Differences (Paired, $p<0.05$) (51% of the Students Participated in Both Pre and Post Survey, Fall 2008).

Statements*	**% Favourable**	
	Pre	**Post**
1. Mathematical skills are important for understanding biology.	17	14
2. For me, biology is primarily about learning known facts as opposed to investigating the unknown.	33	36
3. I think about the biology I experience in everyday life	39	61
4. If I had plenty of time, I would take a biology class outside of my major requirements just for fun.	41	49
5. I enjoy explaining biological ideas that I learn about to my friends.	41	49
6. I think about the ideas presented in biology courses outside of class.	54	62
7. I generally restrict my study to what is specifically given in class and in course outlines.	55	66
8. When I am not pressed for time, I will continue to work on a biology problem until I understand why something works the way it does.	61	52
9. It is important to study biology to help find answers to societal problems (e.g., poverty, climate change).	65	78
10. I do not expect the rules of biological principles to help my understanding of the ideas.	75	64

*These statements are from the final version of the attitudinal survey.

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Table 6
Attitudinal Survey Responses for Statements with No Statistically Significant Differences (Paired, p>0.05) (51% of the Students Participated in Both Pre and Post Survey, Fall 2008).

Statements*	**% Favourable**	
	Pre	**Post**
11. If I get stuck on answering a biology question on my first try, I usually try to figure out a different way to answer it.	12	8
12. If I want to apply a method or idea used for understanding one biological problem to another problem, the problems must involve very similar situations.	25	35
13. Even if I have studied hard for a biology test, I may not get a good mark in it.	26	30
14. I want to study biology because I want to make a contribution to society.	37	36
15. When I am answering a biology question, I find it difficult to put what I know into my own words.	37	42
16. I enjoy figuring out answers to biology questions.	44	45
17. After I study a topic in biology and feel that I understand it, I have difficulty applying that information to answer questions on the same topic.	45	52
18. I actively try to relate what is presented in biology to what I have learned in other courses.	51	51
19. My curiosity about the living world led me to study biology.	51	46
20. I do not spend more than a few minutes stuck on a biology question before giving up or seeking help from someone else.	55	52
21. When studying biology, I relate the important information to what I already know rather than just memorizing it the way it is presented.	56	58
22. Knowledge in biology consists of many disconnected topics.	64	62
23. It is possible to explain biological ideas with everyday language.	66	74
24. There is usually only one correct approach to solving a biology problem.	69	69
25. If I get stuck on a biology question, there is no chance I'll figure it out on my own.	72	72
26. Reasoning skills used to understand biology can be helpful to my everyday life.	75	73
27. Learning biology changes my ideas about how the natural world works.	76	80
28. Learning biology that is not directly relevant to or applicable to human health is not worth my time.	81	80

*These statements are from the final version of the attitudinal survey

Both cohorts of students (years 1 and 2) displayed similar characteristics in regards to their beliefs about biology. When all statements are included to calculate *overall* expert-like responses in year 2, 50% expert-like responses were recorded at the beginning as opposed to

53% at the end of the course. Here, it is important to note that attitudinal changes often takes time and do not happen within the short term of a course.

On the one hand, students came in with rather high expert-like beliefs (>75% agreement with experts) concerning the role of reasoning skills in biology (Table 6, Statements 26-28). On the other hand, they demonstrated rather non-expert like beliefs in problem solving as presented in Tables 5 and 6 similar to year 1 students (as presented in Table 3) in their confidence about solving problems (i.e., generally low confidence and no significant shift in time).

However, in response to statement 3 “I think about biology I experience in everyday life” we observed significant shifts in their perception of the relevance of biology from 39% to 61% favorable (Table 5). More students were able to relate course material to issues and events in their personal lives. Of the many aspects of student attitudes we probed and analyzed it was most gratifying to discover a positive shift in student enjoyment in discussing biological issues. We succeeded in making this non-majors course an enjoyable learning experience for students.

Conclusion

Redesign Process

In navigating the course redesign process we chose a route that consisted of six steps to transform a non-majors biology course from being a lecture-only course of traditional survey of topics to a course focusing on biological issues with clear learning outcomes enhanced with active learning strategies and assessments. We incorporated many aspects of curriculum reform principles described in education literature and collected both qualitative and quantitative data to inform our decisions. The initial demographic and survey data helped to shape the overall learning goals for the course as well as the development of learning outcomes, with engaging learning activities and appropriate assessments. These steps proved effective in guiding our redesign process.

Evaluation of the Redesign

Often the course redesign process is considered complete with the implementation of the new course. We recognized the need to evaluate the new course and consider further refinements. The formation of a collaborative team of instructors and researchers was also essential for the development and implementation of a research plan that involved the development of surveys, data collection and analysis, and ultimately dissemination to the community of teaching faculty and curriculum developers.

Student feedback and documented evidence of student attitudes provided the information we needed to make sound decisions without which the redesign would have been based on faculty perceptions of what was best. The topics through which concepts were presented would have been vastly different and the frequency of active learning assignments would have remained overly ambitious. Initially students were resistant to the implementation of active learning strategies. But once the benefits of these teaching strategies were explicitly explained, most students appreciated the change from the traditional passive lectures. Towards the end of the term it became increasingly difficult to engage students in active learning, providing further evidence that the timing of assignments required careful consideration. We had also anticipated that through instruction using active learning strategies students would be more confident in their conception of biological issues. Instead we found that the students became less confident in their own mastery of solving biological problems. One explanation is that they developed an appreciation of the complexity of these problems and recognized the rudimentary nature of their current knowledge. We needed to acknowledge that students are not always receptive to challenges that are beyond their present conceptual understanding. Finally, the attitudinal survey informed us that we were in part successful in achieving our implicit goal of shifting student attitudes about learning biology. The majority of students in this course acknowledged that studying biology *did not consist entirely of the memorization* of terms and facts but that biological concepts are fundamental to learning biology. Student feedback and evidence of student attitudes was valuable in identifying further modifications needed for the course.

Following course redesign, further revisions continue to be an integral part of our practice. The initial redesign was undertaken in fall 2007 (year 1 pilot), then revised in 2008 (year 2) and further refined in 2009. The current instructors continue to collect feedback from students and make modifications to the curriculum to improve the effectiveness of the course.

We report our experience in the redesign of the non-majors biology course with the intent of sharing our insights with the community of teaching faculty and curriculum developers. This final step in the course redesign process is the dissemination of our work with which we hope will be useful to other instructors considering the redesign of undergraduate courses.

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Supplementary Materials

SM I

Welcome Survey Questions and Responses from Fall 2007. 89% of Registered Students Responded to the On-line Survey.

Welcome Survey Questions		Responses (%)
1. What Faculty are you currently registered in?	a. Faculty of Science (FoS) b. Arts c. Forestry or Land and Food Systems d. Applied Science e. Others	48% 29% 14% 4% 5%
2. What year of post-secondary study are you beginning this term?	a. First b. Second c. Third d. Fourth e. Fifth or more	60% 23% 9% 4% 3%
3. Which of the following describes why you are enrolled in BIOL 111?	a. As a requirement to enter one of the degree programs in the FoS b. As a specific requirement for a degree program that is not in the FoS c. As a Science elective for my degree, which is not in the FoS d. As a general elective that I am interested in e. It is required for further study that I am planning on rather than for my undergraduate degree (e.g., Medical School Degree)	41% 17% 11% 11% 20%
4. Currently, my goal after getting my degree is to	a. Continue on in a graduate degree program in a Biological Science b. Continue on in a professional degree program (DDS, MD) c. Enter the work force in a job related to my degree d. Continue in degree program not directly related to Biology e. Enter the work force not necessarily in a job related to my degree f. Undecided	6% 21% 23% 18% 6% 26%
5. At the moment are you planning on entering one of the degree programs related to biological science?	a. Yes b. No	34% 66%
6. If you are planning on entering one of the Biological Science degree programs, indicate which (at the moment) would be your first choice from those below:	a. Biology b. Biochemistry and Molecular Biology c. Biophysics d. Physiology e. Combined Biology- Computer Science f. Combined Chemistry-Biology g. Combined Microbiology-Computer Science h. Earth and Ocean Science i. Environmental Science	59% 12% 4% 2% 6% 2% 3% 4% 8%
7. Thinking about what interests you about biology, which of the following would say is at the top of your interests?	a. Ecology/evolution (biodiversity, conservation) b. Molecular biology (genetics, cell biology, biochemistry) c. Human physiology and health d. Disease (infectious disease, cancer) e. Ethical issues in biology f. Political/economic issues in biology	23% 18% 26% 23% 2% 8%

SM II

Unit Level Learning Outcomes of the Redesigned Course.

Unit	Topics and Learning Outcomes for Issues-based Course Curriculum (After Course Redesign)
1	**Introduction and Biology as a Science** 1. Devise testable scientific hypotheses. 2. Provide examples of how scientific knowledge is iterative and cumulative. 3. Assess information and data in the media using scientific reasoning.
2	**Life as we Define and Name It** 1. Identify differences among kingdoms and domains. 2. Name common species using scientific nomenclature. 3. Identify 10 common local plant, animal, and fungal species. 4. Effectively use a dichotomous key to identify species. 5. Interpret a phylogenetic tree to identify the degree of relatedness. 6. Explain why the tree of life is constantly revised.
3	**Surviving, the Physical Environment** 1. Identify abiotic factors affecting organisms in their environment. 2. Describe the range of an abiotic factor locally. 3. Describe habitat requirements of local species. 4. Define the composition of biological communities. 5. Describe the effect of changing abiotic factors on the regional or geographic species distribution. 6. Predict the consequences of environmental disturbances on communities.
4	**Interactions, to Eat or What to Eat** 1. Describe the different ways in which organisms interact. 2. Identify the energy sources of different groups of organisms. 3. Distinguish among different types of predation and feeding. 4. Arrange organisms into a food chain or food web. 5. Predict the consequences of food web perturbation. 6. Describe the implications of biomagnification. 7. Assess the efficiency of energy transfer among different food sources.
5	**Population Potential** 1. Identify factors that contribute to population growth, explain how they contribute to population size. 2. Explain what factors determine carrying capacity. 3. Compare real population growth curves to models. 4. Apply a model of population growth to predict changes in population size.
6	**HIPPO** 1. Explain how HIPPO factors contribute to population changes. 2. List factors that contribute to ecological footprints. 3. Calculate your ecological footprint and identify ways to reduce it.
7	**A Catchy Unit** 1. Categorize diseases by causation. 2. Examine how basic cell structures carry out their functions. 3. Distinguish among bacteria, viruses and eukaryotic cells. 4. Explain how bacteria and viruses can disrupt regular cellular or body functions. 5. Predict how infectious diseases spread. 6. Explain how immune systems respond to infections.
8	**Cell division, Disrupted** 1. Describe the organization of genetic material in a cell. 2. Describe the events that occur during the cell cycle including DNA replication and mitosis 3. Predict the consequences of mutations in a cell. 4. Explain how errors in the regulation of the cell cycle contributes to cancerous growth.
9	**Variety, Nature and Nurture** 1. Describe how diploid cells produce haploid cells through meiosis. 2. Explain how meiosis and sexual reproduction contributes to genetic variation. 3. Distinguish between genotype and phenotype. 4. Explain how dominant and recessive alleles in a genotype contribute to phenotype. 5. Analyze patterns of inheritance (Punnett Square, pedigree). 6. Explain how genes are expressed: From DNA to RNA to protein. 7. Identify quantitative traits. 8. Describe how the environment contributes to phenotype. 9. Explain how gene expression is regulated and how cells become differentiated.
10	**Manipulating Genes and Genotypes** 1. Distinguish among biotechnological methods for adding genes to organisms. 2. Describe how genetic material and cells can be manipulated for whole organism cloning. 3. Describe how stem cells are used therapeutically.
11	**Selection In Action** 1. Explain how breeding practices lead to diverse phenotypes. 2. Describe how the natural environment contributes to the selection of phenotypes. 3. Explain how natural selection acts on individuals to shape the characteristics of populations.

SM III

Midterm Survey Questions and Responses from Fall 2007.

Midterm Survey Questions		Responses (%)
1. Are the biological concepts or ideas presented clearly in class?	a. Always b. Most of the time c. Sometimes	21% 71% 9%
2. Do you find the topics introduced in lecture interesting?	a. Always b. Most of the time c. Sometimes d. Rarely	18% 56% 22% 3%
3. Do you find the topics in this course relevant to your everyday life?	a. Always b. Most of the time c. Sometimes d. Rarely	20% 41% 36% 3%
4. Do you find the learning outcomes listed at the beginning of each lecture outline useful?	a. Yes b. Didn't know they existed c. No	75% 10% 15%
5. Do the short in-class discussions help you understand the concepts?	a. Yes b. Only sometimes c. Waste of time d. Nice break	41% 36% 12% 12%
6. How often do you attend class?	a. Always b. Most of the time c. Sometimes d. Rarely	64% 25% 8% 2%
7. How much time do you spend outside of class on this course on a regular basis per week?	a. More than 6 hours b. 3 to 6 hours c. 1 to 3 hours d. None	2% 55% 39% 3%
8. How much time do you spend outside of class on this course before the midterm?	a. More than 6 hours b. 3 to 6 hours c. 1 to 3 hours d. None	1% 17% 47% 35%
9. Do you find group assignments help you better understand the concepts?	a. Yes, they force me to review b. Sometimes c. No, I'd rather work individually d. No opinion	21% 33% 38% 8%
10. Did you find forming groups difficult?	a. Yes b. Somewhat awkward c. Yes, very d. No opinion	38% 37% 18% 7%
11. Would you prefer groups to be formed randomly by either the instructor or on Vista?	a. Yes b. Don't care c. No, I prefer to choose my own group	39% 31% 30%
12. How do you most often communicate among your group members?	a. Meet out of class b. In class c. Email d. Chat or discussion board	39% 13% 47% 1%
13. Do you plan on taking further courses in Biology?	a. Yes b. Maybe c. No	46% 33% 21%

SM IV
Guiding Questions Used in Focus Group Interviews.

September 2007	November 2007
1. Do you think knowing about **Biology is important**? Why or why not? 2. Do you think the topics in this course are **relevant** to your life? 3. Based on what you have heard in the **media**, what areas of Biology do you think you should know more about? 4. What was your **high school experience** in science or Biology like? 5. Do you expect learning Biology to be **different at University** than it would be at high school? 6. What do you think it takes to learn in Biology? What **approaches or strategies** are you using now? 7. What kind of **skills would help you better evaluate** (understand or critique) information presented in the media?	1. Has this course changed your opinion about the **importance** of learning Biology? If so, describe how it has changed? 2. What topics in this course were most **relevant** to your life? How were the concepts applicable to your life? 3. Has this course changed the way you **interpret information** presented in the media (TV or popular print)? What occurs to you when you hear or read about issues in the media that are related to what was discussed in Biology 111? 4. What were **the most important or significant concepts** (ideas) you learned in Biology this term? 5. How did you find learning Biology in University to be **different than it was in high school**? 6. What **strategies** have you used to help you learn Biology in this course? What has worked best for you? 7. What **resources** have been useful in your learning? What skills have been important in your preparation of assignments and in preparing for exams? 8. If someone was asking you **advice** about taking this course next year, what would you tell them? Consider aspect such as the interest level, the rigor, the skills needed etc.