A Task-Centered Approach to Freshman-Level General Biology

Greg Francom*, David Bybee, Mark Wolfersberger, Anne Mendenhall, M. David Merrill

Center for Improvement of Teaching and Outreach, Brigham Young University-Hawaii,
BYUH #1963, 55-220 Kulanui Street,Laie, HI 96762
Email:greg.francom@gmail.com

*Corresponding author (Current address 1081A Pebblestone Drive
Watkinsville, GA, 30677)

Abstract: Many new instructional theories advocate centering instruction around a set of authentic tasks to improve application and transfer of knowledge and help students take more responsibility for their own learning. At BYU-Hawaii, a general education biology course was redesigned to follow this task-centered approach and then taught to two groups of students. Tasks were chosen for this course that required students to first learn and then apply their knowledge of biology. Technology was also brought into the course to help BYU-Hawaii reach its target areas for distance students. Overall, students feel that this course helps them take more responsibility for their learning and is more meaningful than other general education courses to which they have been exposed. Responses to tasks suggest that students who apply themselves learn critical thinking skills within the domain of biology and discuss biological topics in depth.

Keywords: general biology, task-centered instruction, authentic tasks, distance education, student-centered learning, authentic assessment

Introduction

Brigham Young University-Hawaii (BYU-Hawaii) has students from over 70 different countries attending classes. To prepare them better to attend BYU-Hawaii, efforts are being made to teach more students at a distance before they arrive on campus. The present thrust is to convert existing face-to-face, freshman-level general education courses to a distance education or hybrid format, to increase the effectiveness of instruction in these courses, and to help students take more responsibility for their own learning. Students will finish their first year of college in their own country before coming to Laie, Hawaii, where they will finish their degree on campus. The target areas for this approach currently include Mongolia, Korea, Hong Kong, and Taiwan. This approach has many advantages for BYU-Hawaii, including decreasing the need for student housing in a small and very full community, preparing students for college life before they actually attend classes in person, and helping them learn effectively.

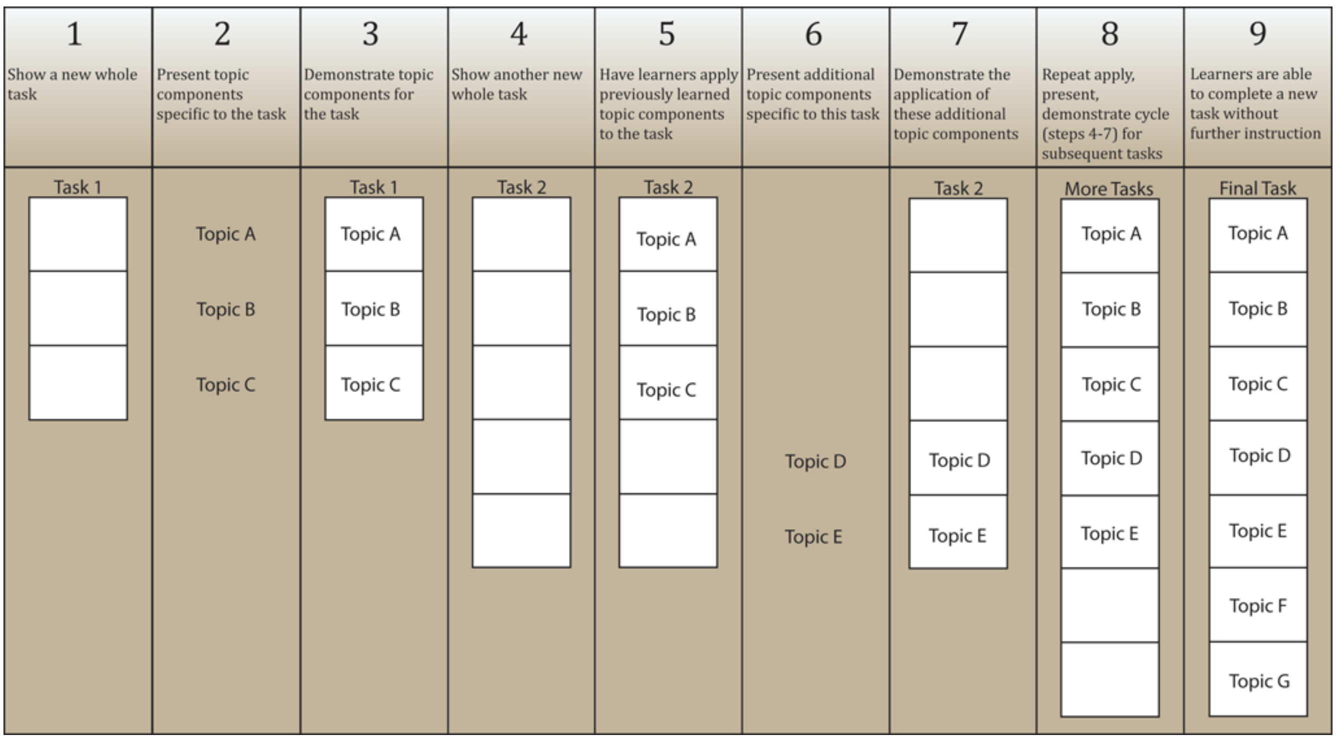
One of the first classes to be converted to this format and taught as a hybrid course was Biology 100. Biology 100 is a general biology course that gives freshman-level students a survey of the field of biology. Traditionally this course covered topics that include the introduction to biology, cells, molecules, photosynthesis, cellular reproduction, genetics, DNA, ecosystems, evolution and much more. Courses such as this that cover a breadth of topics are among the most common types of general education courses in universities today. Many university courses center instruction on topics rather than tasks and cover a high number of topics without requiring students to apply the information they learn to new situations. The passive lecture approach, while common (Lammers, 2002; Ediger, 2001), requires less responsibility from students for their own learning than other more constructivist approaches to learning (Harland, 2003; Brauner, Carey, Henriksson, Sunnerhagen, & Ehrenborg, 2007). Standard assessment methods such as multiple-choice tests that are commonly used in college classrooms, while sometimes able to determine depth of learning, are often used only as a way to encourage absorption and recall rather than application. Too often, students learn a little bit about each item and then remember that little bit for the test without applying it (Butler & Roediger, 2007; Reid, Duvall, & Evans, 2007). Concepts in these types of general education classes are not easily transferred because students have little chance to apply them to new situations (Specht & Sandlin, 1991; Minderhout & Loertscher, 2007, p. 178).

A Task-Centered Model

In contrast, many new instructional theories advocate centering instruction around a set of real world, authentic tasks (Herrington, Reeves & Oliver, 2006; Merrill, 2002a; Merrill, 2002b; van Merrienboer & Kirschner, 2007; Reigeluth, 1999; Lebow & Wager, 1994). An authentic task involves real-world application of knowledge to complete, is closer to something that a professional in the field would do, and applies knowledge from more than one subject area. Reigeluth explains that the first task should be the simplest form of a task that a professional would actually do, and subsequent tasks should increase in complexity (1999, p. 442). Examples of such learning tasks in the domain of biology include requiring students to find out if a certain observed trait is heritable, or having students determine if a certain chemical found in nature is actually man-made. These tasks, while complex, can be simplified and done by students if they are given the necessary support.

Merrill hypothesizes that centering instruction around a set of authentic tasks allows students to form mental models; holistic representations of parts, relationships, conditions, actions and consequences of a complete task (Merrill & Gilbert, 2008, p. 4; Merrill, 2007, 2002, p. 5). Centering instruction on tasks requires students to apply the information they learn in class to new situations. In *First Principles of Instruction*, Merrill prescribes that tasks used in instruction should be demonstrated to the students, and that students should be required to complete multiple whole tasks which apply some of the same information so these tasks can be compared to each other (2002a, p. 46).

Figure. 1. A graphical representation of a task-centered instructional strategy.

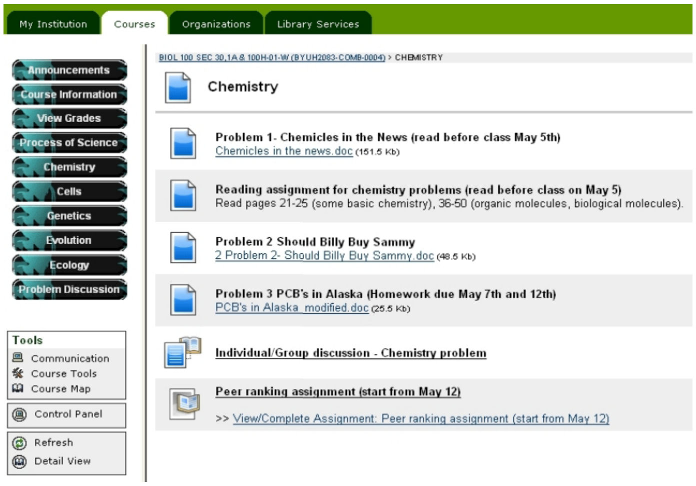


Instructional tasks should be designed to make students apply information they have learned to the task so that the experience of working through the task is added into a student's mental model along with the information (Merrill, 2002b). Instructional strategies that follow a task-centered approach should not present any information to students that is not applied to a task.

The Task-Centered Design

The existing BYU-Hawaii Biology 100 course was converted to follow this task-centered approach. One of the major trade-offs in this process was sacrificing broad information coverage for a deeper coverage of each topic. It takes more time to learn and apply a concept to a unique task than it does to just “skim” the concept. Dr. David Bybee, the Biology 100 instructor, examined his existing course and decided on topics that could be taken out of the course and those that were essential for students to form a foundation in biology. He chose to incorporate tasks into the course that fit within these different areas; the process of science, essential chemistry, cells, genetics, evolution, and ecology.

Figure. 2. The Biology 100 course online.



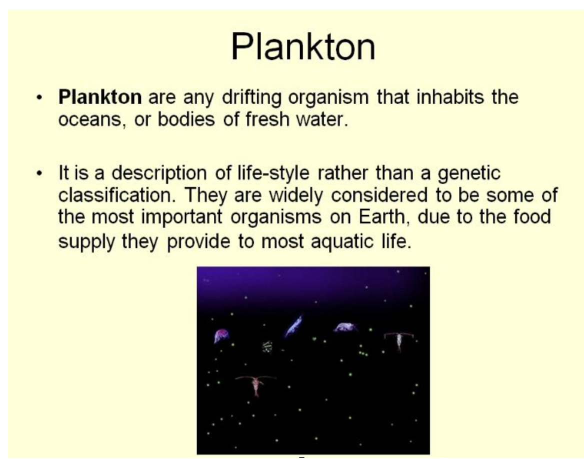
Tasks within these areas allowed students to apply their knowledge of biology to a new situation. For instance, in the process of science section, students learned information about the process of science and then completed three tasks that required application of their knowledge of the process of science. Students were scaffolded (Wood, Bruner, & Ross, 1976) to help them properly apply the information they learned to the tasks through in-class presentations that presented only information that was pertinent to the current task and how the information could be applied to tasks. Scaffolding in this class involved explicitly showing students how to complete the first task in a subject area using information about the process of science, then diminishing the level of support given to students for each subsequent task that students complete in the subject area. Information in the course was applied soon after it was presented. At the beginning of class Dr. Bybee explained to students some of the key differences between this class and a traditional general education class at BYU-Hawaii to help them understand what their experience would be like.

Figure. 3. A chart that was presented to students on the first day of class to help them understand what their experience would be like.

Traditional Class	This Class
Lectures in class	Demonstrations and practice in class
Learn about the same thing students read about in the textbook	Students read before class and come ready to apply what they read to a biology problem
Assessment is done with multiple choice tests	Assessment is based on how well students apply their knowledge of biology to a problem and how well they participate in class
Sit and listen in class	Participate practice and present ideas at the front of the class
Teacher imparts knowledge to students	Teacher and students solve problems together
Less work in class	More work in class
Knowledge is most important	Application of knowledge is most important
No need to be ready for class by reading and studying	Readiness for class will affect student's grades, but more importantly, their learning
What students learn depends on how well the instructor lectures	What students learn depends on how much preparation and critical thinking students do
Not too much fun	A lot of work, and a lot of fun

Basic information presentation, including textbook reading and lecture information has been moved from playing a central to a supportive role. Most of the tasks that Dr. Bybee chose for students to complete required students to understand certain concepts and definitions before being able to complete the task. This information was provided to the students in a variety of formats, including their textbook, classroom presentations and carefully prepared online tutorials. Traditionally this Biology 100 class required reading the entire textbook. In the redesign, students were asked to read only the pages in the textbook that apply to the task at hand. Since the tasks are not bound to a specific subject area, students had to gain background knowledge of additional concepts and definitions. They viewed online tutorials and listened to in-class presentations to give them this knowledge.

Figure. 4. An online tutorial that tells about Plankton.



Student Activities – Before Class

Students were involved in a minimum of three tasks from each topic area. Before each class, students were first presented with a task before learning about the subject area or knowing how to complete the task. Students accessed this task online in a course management system. Students then read their shortened textbook reading and other information that was relevant to the task. Because students had already read the task, the textbook reading was designed to help them gather information to help them complete the task.

For example, in the Ecology section of the class, students were required to read a real-world case study involving a description of trophic interactions in an isolated environment. Then questions were posed to students in this case study about these interactions. The case study and questions made up the first task that students should complete. Students who did not yet have knowledge of ecology would likely not be able to answer the questions when reading the case study for the first time, but they were encouraged to think about how the material presented in the task related to ecology. Students next read about 22 pages of their textbook that were selected because of their relevance to the case study. As students read in the textbook, they were encouraged to look for clues that helped them to complete the task by answering the questions in the case study. In this process of reading and thinking about the task, students began to understand ecology and the task before coming to the first ecology class session.

Student Activities – In Class

In each class, the instructor showed students how the information that they read could be applied to the task. Then the instructor presented a second task but diminished support for the task by demonstrating only a partial solution to the task. The instructor explained how information read in the textbook and elsewhere could be applied to complete the second task. Students broke into groups and solved the rest of this second task with each other. This peer interaction gave students the opportunity to discuss their knowledge of the topic area and task and the relationship between them. They defended their own responses to the task when disagreements arose.

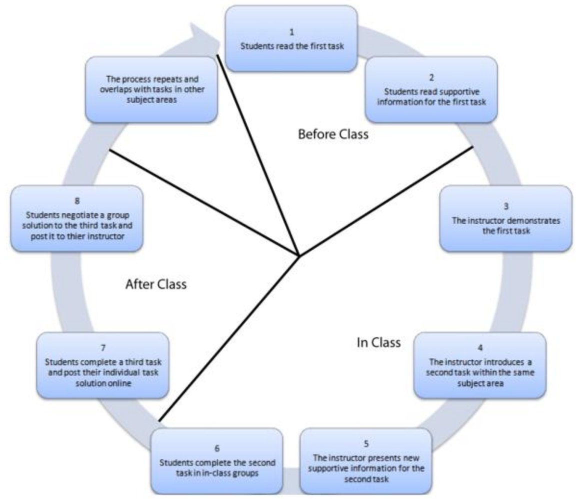


Figure. 5. The weekly student process of before class, in class and after class activities.

Several classroom observations revealed that students participated well in demonstrations and enjoyed the instructor's presentations. Observers also noticed that group discussion time was quite animated. In one class session, students in groups debated and discussed the role of mitosis and meiosis in the redistribution of chromosomes and explained other pertinent genetics concepts to each other.

The task in which students were engaged during one observation was a genetics problem called *Desiree's Baby* (Schnieder, 2003). *Desiree's Baby* is a tragic story about a woman in the 1800's who has a baby that begins to show signs of mixed race in skin color. Her racist husband requires her to leave. Heartbroken, Desiree takes her own life and her baby's. Later the husband discovers that he is actually the person whose family line contains mixed race genes. The task required students to apply genetics to this story by discussing their knowledge of inheritance patterns and draw conclusions based on this knowledge. This story was not sanitized of other topics such as racism and 1800s culture, which was one reason that it was interesting to students. Almost all students were taking very active roles either explaining a concept or listening to one another. Many students also referred to their textbook and websites via laptop for more information on genetics.

Student Activities – After Class

After each class, students worked on a third task. In the genetics section, students worked on a case study about the occurrence of people with blue pigmentation in their skin (Leander & Husky, 2008). Their homework was to determine possible causes of this skin pigmentation, how to test for these causes, and whether this blueness in the skin is a heritable trait based on family trees. Students posted individual answers to these problems in an online course management system and then compared their answers to those in their group of up to 4 people. Then, as a group they negotiated a final response to submit to their instructor. Because the task was complex, there were a variety of answers given by individual students and groups. Most students hypothesized that perhaps the level of oxygen in the red blood cells was low for varying reasons, mainly genetics. Other responses speculated about the introduction of foreign drugs into the body, or environmental and lifestyle circumstances. Students also indicated ways that they could test these hypotheses, including studying the family tree of the people involved or studying the environment in which they live. Here is a quote from one of the group responses:

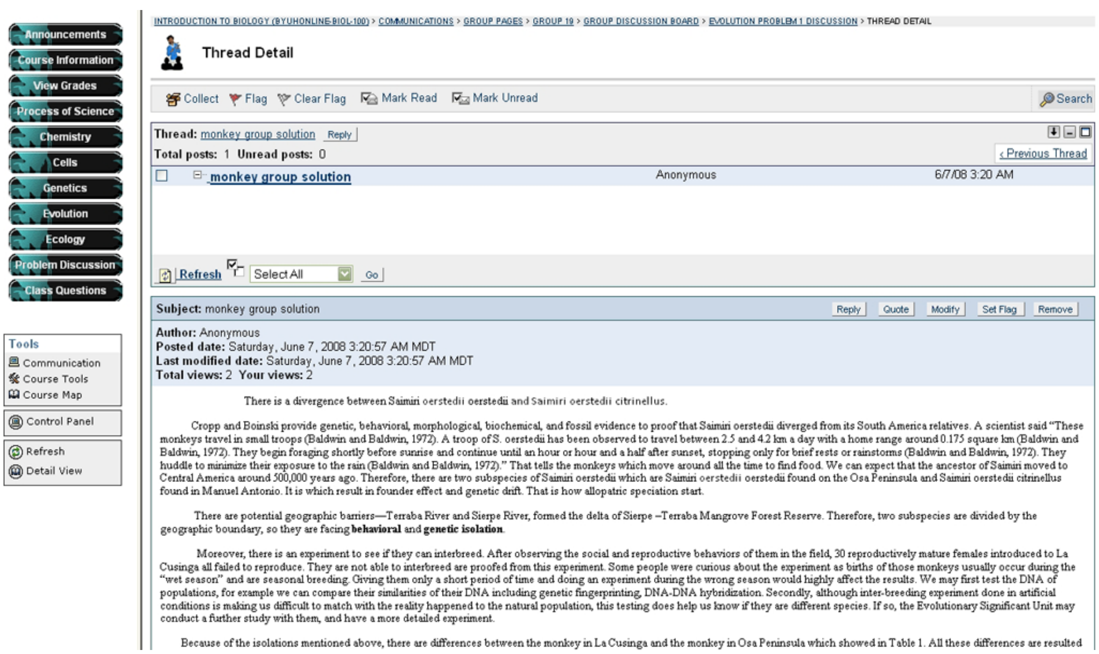
> The first [...] hypothesis that we considered was that this skin formation was [due to a lack] of a certain enzyme called diaphorase, as a result, blood levels of those who suffer from met-HB (methemoglobin) have a shortage of oxygen-carrying competence, also because this triggers methemoglobin levels [to] soar. Therefore, it is represented in the human being by the bluish tinge found on their bodies.
> To test this particular idea, we would compare blood samples of those who suffer from met-Hb and those who do not, and devise a way to measure the oxygen levels [in] the blood streams.

Another response to the same problem given by a different group of students includes the following observation;

> There was always someone within the pedigree chart who was a carrier of the recessive methemoglobinemia (met-H) gene, which limited and/or stopped the body's production of the enzyme diaphorase (which breaks down methemologbin into hemoglobin in red blood cells). The absence of this enzyme produced a disproportionate amount of methemoglobin in the blood, tinting it blue [...] People aflicted [sic] with this genetic disorder have skin which is literally purple-blue in color and dark purple lips. The hemoglobin in their blood has a reduced ability to carry oxygen which produces the blue color of their skin. The dominant, normal allele is responsible for the production of an enzyme (protein), called diaphorase that reduces the hemoglobin so it can be reused and pick up more oxygen.

All student group solutions included a family tree that represented the family in question and listed their traits in a genetic chart. Other unit tasks were similar to this one. Students were required to post their individual response to the task and then discuss each other's responses online in groups and decide on a final group response. Dr. Bybee observed that, relative to his traditional general biology class, students who invested their time in these online discussions were involved in a deeper level of discussion, and had an increased feeling of the importance of biology as a field of study.

Figure. 6. A group solution to an ecology problem in the Biology 100 online discussion board.



Assessment

In contrast to the traditional method of general education biology teaching at BYU-Hawaii, which often uses multiple choice tests to assess students' understanding of biology, a student's grade in this Biology 100 course is based mostly on authentic methods of assessment that determine how well they can apply information to a unique task. Assessment in the Biology 100 course is based on three main components. First and most importantly, a student's individual posts and group responses are graded based on how well they apply their knowledge of the topic area to the task, how thoroughly they outline the topic area, how well the evidence from the task is used to complete it, how well items read in the textbook and experiences in the class are applied, and grammatical correctness. These elements were part of a grading rubric used by the biology instructor to assess the ability of students to apply the knowledge they learned. Next, students report on how well they prepared for each class by choosing from options in a specific rubric. Finally, students rank each other on how well they contributed in the group work during each task.

Authentic assessment, including grading students ability to apply information to a task, focuses on deep understanding and application of knowledge (Gulikers, Bastiaens, & Kirschner, 2004; MacAndrew & K. Edwards, 2002; Oh, Kim, Garcia, & Krilowicz, 2005). Authentic assessment measures given by the instructor when measuring the application of knowledge have been found to be reliable and valid with high inter-rater reliability between internal and external experts in both written responses and oral presentations (MacAndrew & Edwards, 2002; Oh et al., 2005). Authentic assessment methods have also been found to measure application of learning rather than just "surface" learning (Reid et al., 2007; Gulikers, Kester, Kirschner, & Bastiaens, 2008). Self-grading increases student responsibility for learning and has been found to be a valid method of assessment when students follow a specific rubric (Edwards, 2007; Sadler & Good, 2006; Strong, Davis, & Hawks, 2004). Cheating and grade inflation are possible risks in self-grading, but studies have shown that the benefits of self-grading, including increased motivation and learning opportunities often outweigh the risks (N. M. Edwards, 2007; Strong et al., 2004). Peer-ranking as an assessment technique has been used in a variety of situations with high reliability and validity (Cho, Schunn, & Wilson, 2006; Magin, 2001; Wen & Tsai, 2006) especially when used with forced distribution (ranking) (Ryan, Marshall, Porter, & Jia, 2007).

Evaluation

Biology 100 has gone through one iteration of formative evaluation. This formative evaluation was conducted at BYU-Hawaii as a hybrid course with 89 students in 2 classes. Student perception results from this pilot test will be used to help BYU-Hawaii bring general biology to its target areas. The instruments of the evaluation included classroom observation, instructor observations, a class survey, and online discussion observations.

Students took a little while to get used to the format of this course which is radically different from other courses that they have taken at BYU-Hawaii. At the beginning of the course students had to learn to use an online learning management system, negotiate an unfamiliar grading scale, and learn to increase responsibility for their own learning. The perceived frustration level among students in the classes decreased from high at the beginning of the semester to low as students got used to the course format. Almost all other courses at BYU-Hawaii require attendance, so when this course did not require it, some students took the liberty of not coming. Despite all of the warnings given to students about how this course would be different than what they are used to, some students still treated this course as a traditional higher education course. As time goes on and more courses give more responsibility for learning to the students, they will likely begin to understand how to take that responsibility seriously.

Several classroom observations showed that overall, students actively participated in class discussions. However some students decided not to take responsibility for their own learning and avoided group discussion. Discussion groups were usually formed by culture and friendships since students were allowed to form their own groups. Plans are being made to conduct an instructor training that will help address some of these concerns. Group formation will be changed to make sure that small and cross-cultural groups will be formed and to require more effective participation.

Throughout the course, students' task solutions showed that they gained a deep understanding of biological topics. Dr. Bybee observed that some of his freshman students in this Biology 100 course were able to complete problems and tasks that he had used with his senior level students. This observation suggests that this course helps students learn critical thinking skills within the domain of biology and make conclusions that are similar to ones made by more experienced biology students.

88 students responded to an online survey about the Biology 100 class. Ninety-two percent agreed that this class gave them the opportunity to apply knowledge in meaningful ways. Over 81% felt that their interest in Biology increased as a result of this

class. Over 76% liked this class better than other general education classes they had taken. At least 92% of students felt Biology 100 helped them improve their critical thinking skills and 76% felt that it helped them improve their reading and writing skills.

Of course, not all survey responses were favorable. Almost 60% of students felt that online discussions were the least helpful activity to their learning. Observations on these discussions indicate that some students did not take these activities seriously, and some of the online discussion tasks were not complex enough to allow for differing solutions. Many (68%) students felt that the required readings (tasks, and textbook reading about the tasks) were the most helpful activities for their learning.

When responding to, "I would suggest the following items to improve the Biology 100 class for future students," Student responses generally fell into four areas: improve grading and feedback to make it more prompt, improve the organization in the course so that students understand their expectations, remove the peer-ranking elements of the course, and mandate in-class attendance. Other responses not in these categories include the following: "Please give us class more than once a week. Please destroy the grading system and rework it entirely. Please don't turn a teacher into an online supervisor for an internet course." Another student showed his/her desire to return to a traditional course format with the following comment, "Stop using blackboard and stick to the system that works- tests and quizzes."

Students also responded to the statement, "I especially liked the following aspects of the Biology 100 course," and responses to this statement also fell into four main categories: problems that allow learners to apply information to a unique situation, the lack of exams, the instructor's presentations, and in-class and online group work. One sample response to this statement illustrated a common feeling of satisfaction in being able to apply information to tasks: "The problems, how applicable everything was to real events and life [...] It was so awesome, and so helpful for applying book-knowledge to real life. LOVE it!" Another comment highlighted student responsibility for learning in the class:

> What I did like is the idea behind the class. Its [sic] much more geared towards effective learning because its more about the education rather than memorizing for the test. I think the philosophy of the class is unique because it allows kids to really learn if they take the time to apply themselves. its [sic] a bit more self guided than other classes so the students need to be serious about learning.

Another student responded with enthusiasm for the lack of tests in the class, "No tests! i [sic] liked the learning method of learning through our own analysis and discussions with others, it was new and interesting..."

One student's response summed up the main purposes of this course redesign:

> The readings helped me understand the basis for what we were discussing, and in-class discussions and instructor presentations helped me to focus that knowledge and come up with possible solutions to real problems. On line discussions helped me to develop my critical thinking skills more on my own because I was forced to come up with my own hypothesis, and argue either for or against others. This helped to hone my ability to think in a way that applied both what I learned from being in class, from the readings, and from outside information and logic. I LOVED this class!

Discussion

The observations and survey findings indicate that overall, students were excited and motivated in Biology 100. They especially enjoyed being able to apply information to complete relevant tasks and take more responsibility for their own learning. Most students preferred this method of teaching to other general education teaching methods to which they had been exposed. One limitation to the findings is that there was no systematic comparison of the performance of this class to another similar general biology class taught in the original way using lectures and tests. Using both authentic and traditional assessment in each class would help determine what types of knowledge students are learning and allow a comparison between the different classes. Another limitation is that the original Biology 100 final was not administered to students in this Biology 100 course. Results from the original final would indicate if students actually did gain a general knowledge of biology concepts in addition to the applied knowledge already measured by the instructor in students' task solutions. The focus of this course was application of concepts rather than memorization of biology concepts, but results from the original final would indicate if students actually did remember concepts through their application. A third limitation is that individuals who had a stake in the outcomes of classroom observations did these observations. So confirmation bias could have played a part in the report of classroom observations despite the observers' efforts to be objective.

Revisions

Based on the survey results, feedback will be improved to give grades promptly for student performance. Problems will be examined for complexity and some will be switched out for more applicable problems that will help improve group discussion. Future revisions to the course include conducting a traditional final test for all students and peer grading of group solutions to tasks is also planned to allow students to review and learn from each other's group solutions.

Revisions are currently being made to the Biology 100 course to prepare it to go out to its intended target areas. It is planned to be tested in Asia in January, 2009. Further evaluation data will be gathered to investigate the effectiveness of this approach to teaching general biology to BYU-Hawaii's target areas.

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