Conversion/Immersion: Writing Case Studies

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Biography

Peggy Brickman is an Associate Professor at the University of Georgia where she teaches Introductory Biology for non-science majors. She was awarded the Sandy Beaver Special Award for Excellence in Undergraduate Teaching in 1999, a Richard B. Russell Undergraduate Teaching Award in 2006, and the Board of Regents' Teaching Excellence and Scholarship of Teaching and Learning Award in 2007. Her research examines student engagement and learning as well as graduate student training. She received her Ph.D. from the University of California at Berkeley.

Norris Armstrong is an Associate Professor at the University of Georgia where he teaches Introductory Biology for science majors and non-majors. He was awarded the Sandy Beaver Special Award for Excellence in Undergraduate Teaching in 2006. He research examines ways in which to improve student engagement and learning outcomes in very large science classes. He received his Ph.D. in Zoology from Duke University.

Introduction

Traditional classes often present course material as isolated information without strongly linking the concepts being taught to students' existing knowledge, experiences, or interests. Lacking such reference points on which to base their learning, students often resort to memorizing rather than truly understanding the information being taught. Case-based learning attempts to address this dilemma by presenting course material in the context of story. Students apply the concepts in a meaningful way as they relate to the story and attempt to address a controversy or solve a problem that has been posed.

This Conversion Immersion workshop introduced participants to the characteristics of Case Studies and the various settings in which cases can be used. It also provided a setting in which participants could work together in small groups to create outlines for their own cases that could be used to teach basic concepts either in a lecture or a laboratory format. The Wednesday session had 20 participants and the Thursday session had 17 participants. This paper summarizes the information given out during the workshop and the ideas generated by participants.

What are Case Studies?

Below is a brief overview of case studies and how to create them. This interpretation is based largely on work compiled at the University of Buffalo Case Studies website. (http://ublib.buffalo.edu/libraries/projects/cases/case.html). This website is an excellent resource for both beginner and seasoned Case Study users and we refer readers here for a more detailed discussion of Cases Studies than is possible in this manuscript. We have also provided links, when appropriate, to specific articles discussing cases studies.

What are cases?

A case study, as we define the term, is an approach for placing the content information you are trying to teach into the context of a story that your students will find relevant and interesting. The stories used in a case are more than just anecdotes. They strongly influence how concepts will be covered during class and provide students with the opportunity to apply these concepts in a realistic setting. Indeed, cases are frequently based on actual events or situations that students may have heard about previously. Cases can also encourage students to practice critical-thinking skills by asking them to analyze data and evaluate conflicting viewpoints. A good overview of cases can be found at: http://ublib.buffalo.edu/libraries/projects/cases/teaching/whatis.html.

What cases are not.

Cases are not lectures with interesting stories sprinkled in. A good case provides students with opportunities to evaluate data, apply their understanding of the material being covered, and to discuss conflicting viewpoints either in small groups or as a class. As much as possible, students should be given the chance to discover information for themselves. As a result, there can be a significant amount of time during which the instructor should not be talking. A list of suggestions for what NOT to do when developing or teaching a case can be found at: http://ublib.buffalo.edu/libraries/projects/cases/teaching/dont.html.

Important things to consider when developing a case:

Cases Studies can use a variety of formats to achieve many different goals. However, there are a number of things that most cases need to address in order to be successful. We have tried to summarize some of these points below.

- **The story**: The background story used in a case must be closely tied to the concept(s) being taught. Interesting stories may grab students' attention, but will not promote learning unless they get the students to think about the concepts you are trying to relay. Similarly, a case in which the story is not relevant to the content information being taught will seem disorganized and could potentially detract from student learning.
- **Delivery**: How a case is delivered can be as important as the story itself for catching and keeping student interest. It can also influence how you will want to introduce the concepts being covered by the case. Tips on writing readable cases can be found at: http://ublib.buffalo.edu/libraries/projects/cases/teaching/flesch.html.
- **Big picture or specific concepts?** Cases can be used to get students thinking about broad themes ("the big picture") or about specific concepts. However it is difficult to address both of these using a single case, especially a case that lasts for a single lecture. You should be clear of what your objectives are for a class before you begin to develop the case. This same principle is espoused by proponents of the "backward design" approach to curriculum development. A detailed discussion about this approach can be found at: http://www.ascd.org/portal/site/ascd/template.chapter/menuitem.5d91564f4fe4548cdeb3ffdb62108a0c/?chapterMgmtId=4188fa36dfcaff00VgnVCM1000003d01a8c0RCRD
- **In-class activities**: A good case gives students the opportunity to apply their understanding of a concept. This helps to engage the students as well as makes the class more active. Just a few examples of activities that can be used:
    - Provide students with a variety of information resources and have them identify which information is most relevant or important for situation they are addressing.
    - Give different students different background information on the topic being covered. Have the students report what they have learned to their groups, develop an integrated picture from the different sources of information, and reconcile the potentially different points of view. This is also referred to as the Jigsaw method. http://ublib.buffalo.edu/libraries/projects/cases/teaching/jigsaw.html
    - Give students data that they must analyze in order to answer a question.
    - Ask students questions to make sure that the class is up-to-speed with what has happened in the case so far.
    - Ask students to share their ideas or express opinions either in small groups or with the class.
- **Timing**: When developing a case, you must plan to set aside time during which students are working on the problems that have been posed, finding information, or discussing ideas with each other or the class. Depending on the case, this can add up to a significant portion of the available class time.

- **Length**: There is no “appropriate” length for a case. One case may address a single concept and use only a small part of a class period while another may address several concepts and require multiple classes to complete. More important than case length, is whether the case helps the students learn the concepts it addresses.
- **Teaching Notes**: Developing a detailed set of notes for how you plan to teach the case helps you organize the case more effectively an can help you identify potential problems before the class even meets. A good set of notes will also enable another instructor to use your case without having to reinvent the wheel. If you wish to publish your case on the Buffalo Case Studies website, teaching notes are required.

Results of workshop sessions

After an introduction to Case Studies, participants suggested ideas for topics that could be developed into a Case-based format. The participants then assembled into groups based on which topics preferences and reported their progress at the end of the session. Because of the time limits of the workshops, much of the work completed was in the form of outlines that describe how the Case might be constructed.

Group 1: Evolution, Hardy Weinberg and Population Genetics

Participants: Linda Dion, Gillian Gass, S. Catherine Silver Key, Michael O'Donnell, Jennifer Petruniak, Margaret Powell, Kellie White, and Sarah Jardeleza-Winger

Learning Goals

After the Case has been completed, students will be able to:

- Apply and using the Hardy-Weinberg equation
- Evaluate reasons for populations not being in equilibrium and mechanisms for change including natural selection.
- Understand the difference between what is referred to by the terms gene/allele/, genotypes/phenotypes
- Use mathematical models that apply Hardy-Weinberg and Chi squared tests.

Assessments to evaluate student learning:

- Exam problems that ask students apply what they've learned from one population to another and evaluate whether a population is in equilibrium or not.
- Students, as a group, write a 1-2 page paper about a human disease. This project would include peer review of the final product, evaluation within student groups regarding the contributions of individual group members, and an instructor-designed rubric.
- Students are asked to design studies in order to determine whether a population is in equilibrium or not.

Story line for the case:

In athletics, officials test for steroid-use by examining urine samples from athletes for the breakdown products produced when the body processes testosterone and other steroids. The gene UGT2B17 codes for one of the enzymes responsible for this process. The rate of steroid breakdown and doping test results are highly dependent on the genotype of the athlete for UGT2B17. (Schulze et.al., 2008. J Clin Endocrinol Metab. 93:2500-6)

Students would be provided with a table of genotypes and allele frequencies for different groups and asked to use the Hardy-Weinberg equation to determine whether illegal steroid use is likely to be detected or not for each group.

Group 2: Cell Differentiation

Participants: Jane Caldwell, Blanche Hanning, and Kathleen Verville

Learning Goals

After the Case has been completed, students will be able to:

- Tie together concepts such as cells, cell division, migration, signaling, nature of gene, gene activity, gene controls, and tissue formation.
- Diagram key cellular events and molecular events from fertilization to differentiation. (mammalian focus)

Assessments to evaluate student learning:

- Students would be asked to prepare individual project/posters that describe a birth defect and its possible causes
- Students would be asked to give a group presentation on an aspect of cell differentiation.

Story line for the case:

1. A community experiences a higher rate of birth defects than surrounding populations. The cases would examine hypotheses as to the possible causes for the birth defects such as pollution (mercury, pesticides, etc) or medications (e.g. thalidomide, acne medicines, etc.). Students would propose experiments using model systems (fish, chickens, mice) to test their hypotheses.
2. Students serve on an FDA panel evaluating a hypothetical new drug. They must decide whether the drug should be approved for use by pregnant women.

Group 3: Animal Diversity

Participants: Winona Gadapati, Bill Glider, Maggie Haag, Marielle Hoefnagels, and Catherine Webb

Learning Goals

After the Case has been completed, students will be able to:

- Understand evolutionary relationships
- Understand how to construct a phylogenetic tree (morphological vs. genetic criteria for grouping organisms)
- Characterize physiological/organ systems/locomotion in terms of selective forces
- Categorizing an unknown specimen
- Appreciate diversity of life (and potential uses of the organisms or consequences if the organisms go extinct)

Assessments to evaluate student learning:

- Show video clips and have students identify how many types of animals they observe.
- Have students construct a phylogenetic tree or fill in blanks on a partial/blank tree.
- Which of these organisms is most likely to have ___ trait considering its habitat?
- Describe the habitat and predict the types of organisms you might find.
- Show examples of known organisms (acoelom, pseudocoelom, coelom), show how they live, and have students figure out for themselves what the coelom does. What selection pressures would lead to the formation of a coelom?

Story-line for the case:

This Case would last several lab sections.

Expedition: The student's have a friend who has recently started a biotechnology company, and s/he has hired them as biologists for the company. Their boss hands them some papers on the production of defensive chemicals that might be useful for medical purposes. Some taxa produce more of these chemicals than others and the students need to determine which habitats are likely to have more of these organisms. Alternatively, students can be asked to explore whether organisms that produce defensive chemicals [flatworms, sponges, echinoderms] are related by a common ancestor or whether they share this trait because of convergent evolution. As part of their job, they will visit four habitats that are biodiversity hotspots (species rich) but are also endangered. These different habitats would display different selective forces. Example could include coral reefs, tropical jungles, and deep sea/hydrothermal vents.

Activity: Instructor provides a large list of organisms. The students must predict which are most and least likely to have defensive chemicals and should be examined more closely (to save time and the cost of testing every single organism sampled). This activity would require that students to be given background information on selective forces that promote production of defensive chemicals.

Activity: The students will focus on "worm-like" organisms (flatworms, nematodes, earthworms, leeches, lancelets, lamprey, caecilian, millipedes, centipedes, snakes, eels, sea cucumbers, planula of cnidarians, caterpillars, maggots) found in various habitats and will construct a phylogenetic tree based on morphological characteristics. Students will compare their polygenetic trees to one produced by biologists and explain what additional types of information biologists may have use to construct the current view of the evolutionary relationships between the organisms they examined.

Activity: After having been provided students with background information on phylogenetic relationships, students match unknown organisms [rotifers b/c they don't fit, annelid like a leech or polychaete, roly-poly, frog, limbless lizards] against a set of reference organisms and figure out where the unknowns fit on the tree.

Activity: The students' boss is interested in inverts and they must make the case that vertebrates are equally important from a commercial point of view.

Activity: The students are asked to develop and argument for the preservation of these critically endangered habitats.

Group 4: Photosynthesis

Participants: Lee Ann Anderson, Rachel Falk, Carla Starchuk, and Beth Whitaker

Learning Goals

After the Case has been completed, students will be able to:

- Understand basic (general) photosynthetic pathways.
- Understand the relationship between available light (electromagnetic spectrum) and photosynthesis.
- Identify variables that would affect photosynthetic rate.
- Understand the difference between autotrophs and heterotrophs.
- Understand the role of photosynthesis in ecosystems.

Story line for the case:

The students are part of an exploration team that has been tasked to set up a self-sustaining space ship/colony. To accomplish this, they must optimize plant growth to provide both food and oxygen taking into consideration light intensity, photosynthetic rate, and other variables. This lab could be tied into traditional photosynthesis labs.

Group 5: Chemistry

Participants: Margaret Cooper, Marielle Hoefnagels, Susan Moore, and Melanie Rathburn

Learning Goals

After the Case has been completed, students will be able to:

- Describe the structure of the atom.
- Explain how covalent bonds form between atoms.
- Predict which bonds are polar based on electronegativity differences.
- Explain how bond polarity contributes to chemical behavior.
- Explain the molecular structure and chemical behavior of water.
- Recognize a hydrophilic/hydrophobic functional group and/or molecule.
- Recognize the major organic molecules in life.
- Describe how the structures of the organic molecules contribute to their functions.
- Explain how we acquire the organic molecules in food.
- Describe how the organic molecules interact with water.

Assessments to evaluate student learning:

- Build an atom: use the atomic number that corresponds to the month of your birthday, and then find someone else in the room they can bond with.
- Have students be protons, neutrons, and electrons, then pairs of electrons and act out covalent bonds between atoms
- Clicker questions:
  - How many of these bonds are polar/nonpolar/ionic?
  - Arrange these functional groups in order of polarity.
  - Which compound is hydrophilic/hydrophobic?
  - Which of these is a sugar/amino acid/etc.?
- Have chains of students fold into a polypeptide based on polarity of amino acid side chains.
- Look at this nutrition label and tell what sorts of molecules are in it.
- Dissect processed foods in lab.

Story line for the case:

As part of the search for possible life on Mars, scientists have made several attempts to determine whether there are or have been significant levels of water on this planet. Students could be asked to write a blog, a letter to a child, or a report to a government agency explaining why it is important to look for water. Alternatively, students could be asked develop a plan to collect evidence that life has or currently exists on Mars. The idea the group was worked out in greatest detail was for the students to assume that they are responsible for responding to questions posed by the general public regarding the Mars mission. Some example questions might be:

- What elements are abundant on Mars, and are they the same ones that are in life on Earth? Previous research has generated a table that compares the elements on Mars (both on the planet and in the atmosphere) to those on Earth. This information could be given to the students to help them answer this question.

- Is it possible for water to be on Mars?
- Is it possible to have organic compounds on Mars?
- Based on the elements present on Mars, which inorganic compounds on Earth could also be present on Mars?
- Mars is called the Red planet because of an oxide of iron, and there's a CO2 atmosphere. What do these inorganic compounds look like? Draw a model of it.
- Why is NH3, which has the same molecular weight as H2O, a gas at room temperature while H2O is a liquid? Many students may assume that NH3 is a liquid based on practical experience. Students would need to compare the structures of other small inorganic molecules (H2, O2, NH3, CO2) to water and show how asymmetrical shape and polarity contribute to hydrogen bonds.
- Water can be used to dissolve a lot of things, but not oil. Why is that?
- I know that we're going to have to grow plants on Mars; how do plants take up water? These questions would introduce the topic the cohesion and adhesion properties of water.

After several questions, the instructor ties it all together with a discussion of how these properties make water essential to life on Earth [solvent, participant in chemical reactions essential to life, surface tension, cohesion, adhesion, ice floats, etc.] and surmise that it would probably be important on other planets too. This is the reason why scientists focus so strongly on water as a proxy for life on Mars and other planets.

Group 6: Transcription and Translation

Participants: Isabelle Barrette-Ng, Mindy Thuna, and Teresa Weglarz

Learning Goals

After the Case has been completed, students will be able to:

- Understand how RNA polymerase recognizes promoters.
- Understand the process by which DNA is used to make RNA, which is used to make protein.
- Distinguish between template from non-template strands and determine the direction of synthesis during Transcription and Translation.
- Understand how a phenotype can arise from a genotype.
- Identify a promoter, transcribe DNA and translate RNA.
- Understand the basis and mechanism of Polymerase Chain Reaction (PCR)

Assessments to evaluate student learning:

- Ask students what they would need in order to construct a genetically modified organism (GMO) that makes a particular protein.
- Give students an example of how to make transgenic organism and ask them to describe the steps of this process in small group discussions.
- Ask students how they could make GM rice with the gene BT63? How does the gene work and what does it do? Why would they want to make this modification to rice?
- Ask students to predict the sequence of a protein produced by a given DNA sequence. Different levels of complexity could be used for different classes including promoters, terminators, start and stop codons, etc.

- Have students design a test that would allow them to determine if an organism or agricultural product contains an altered gene.
- Ask students what other products contain BT? Are they approved in the U.S.? What are the consequences?

Story line for the case:

Students are asked to assume that they are FDA researchers following an increase in pet deaths from contaminated food. They are aware of a strain of modified, insect-resistant rice (BT63) containing the CRY1AC toxin gene that was developed in 2006 and that some overseas producers are using. However, this strain of rice has not approved for feed or food anywhere in the world. The FDA has received samples from a recent shipment of animal feed containing rice. The students have to test whether or not this shipment contains rice from a BT63 crop. (Based on the article Huggett, B. 2008. Nature Biotechnology 26 (1038): 478)

Group 7: Botany

Participants: Heather Addy, Laura Buchynski, Annette Golonka, Tanya Noel, Amber Reece, Karen Romanyk, and Lori Rose

Learning Goals

After the Case has been completed, students will be able to:

- Recognize or differentiate between plants such as dicots and monocots, and/or make finer distinctions between more closely related species. More aspects could be added to the Case if desired such as algae or other organisms. The case could also be customized for specific geological areas or campuses.
- Understand plant diversity and how to identify a plant.
- Use morphological and DNA to ID plants.
- Use a Dichotymous key.
- Conduct a microscope analysis of plants.

Assessments to evaluate student learning:

- Terminology would be covered using pre-lab homework or quizzes.
- Clicker questions in class to gauge understanding.
- Peer evaluations for group activities.
- Students are asked to design methods for identifying plants.
- Students are asked to serve as an expert witness at a trial or as an environmental investigator in which evidence from plant material must be identified.
- A final assessment would ask students to apply what they have learned about plants in some format.

Story line for the case:

- A man reports that his car went off the road into a pond and his wife drowned. Students are asked to serve as expert witnesses at the trial to identify evidence (plant material found on her body). What part of a plant is this (plant anatomy)? The students would need to use Systematic-keys to identify the plant material (E.g. Monocot versus dicot.) Additional evidence could be added. E.g. water in the victim's lungs and students would be asked to identify the organisms found in this water. Wood fragments found in/on the victim's body.

Evidence would indicate that much of the plant material matches what grows in the husband's yard rather than plants growing around the pond.

- Activities: The students are provided with the story and begin to analyze the plant materials entered into evidence. What part of the plant is it? Students need to determine what features they will look for. Once they have determined if it is stem or root, etc., they will need to key out and compare to specimens of other plants and other organisms (DNA could be used.) Additional labs could include a coroner's report (water samples from the lungs, etc.) that would require additional identification.
- This Case would require materials such as samples of plant tissues from the body and specimens of native plants found around the pond (customized for your own area! Plant material is all dicot, all pond plants monocots). Pollen or seed samples could also be added.

Group 7: Community Ecology Lab or Lecture

Participants: Ralph Preszler and Mark Walvoord

Learning Goals

After the Case has been completed, students will be able to:

- Understand community biodiversity.
- Quantify how biodiversity can change and what causes these changes (human and natural disturbance)
- Understand why biodiversity is important.
- Identify the importance of species diversity and evaluate what affects biodiversity has on an ecosystem.
- Discriminate between different species and quantify biodiversity.
- Propose predictions on how changes in biodiversity may affect an ecosystem.

Assessments to evaluate student learning:

- Use field guides to identify species and quantify biodiversity
- Have students evaluate human impact and biodiversity and the changes these impacts cause.
- Discriminate between graphs/data sets to determine which locations have more/less diversity.
- Identify specimens in labs and using dichotomous keys or genetic sequences.
- Look at series of hypothesis about diversity change in an area and match to a series of predictions.
- Clicker questions, walkabouts, outcome/presentation at the end of the case. .

Story line for the case:

Present students with scenario that requires a solution. Example: Their family has inherited land (forested) and they need to determine what they will do with this land. Alternatively, the student may have inherited some degraded land and want to restore it. How could they do this? Students would work in groups to come up with options: cut the land, keep it as is, alternative land uses. They would need to consider factors such as: fire danger, endangered ecosystem, potential for bioprospecting, family value (sentimental), profitability for logging, erosion, blockage of neighborhood road or stream. The students would then need to estimate the aesthetic and economic value of the land using authentic data. (Property values, emotional value, future value, and other economic data.) The students would then be able to request data that will help them make a decision (plant species diversity in a cut versus uncut area that they have to identify, photos, quotes from grandparents and neighbors, economic patterns, etc.). It would be nice if a field trip could be included to let the students collect materials (alternatively the instructor could provide a bag of sample materials). At the end of the case, each student must make an individual decision, commit to it and justify it.

Resources:

Creating Cases: A step-by-step guide.

Pick your topic, and then for that topic, fill out this worksheet

1. **Define Your Learning Goals:**
    - What key information (facts, terms, concepts, relationships) is it important for students to understand and remember about your topic? (Biology Concept Inventory)
    - What higher-order learning do you envision students using? Complete this sentence: Students should be able to ______________________*
      (*Some great action words: implement, demonstrate, compare, attribute, organize, analyze, discriminate, contrast, judge, justify, evaluate, design, plan, and produce. Think about what connections you want students to make among ideas in your course or with other courses.)
    - What important skills do students need to gain? Consider your student's needs.
2. **Assessment:**
    - What will students have to do, to demonstrate that they have achieved the learning goals as listed in #1 above? Think about how students will actually be using this topic in their lives and try to make it real. If these are non-science majors who will be working in the business field, the most authentic assessment might be for them to develop an advertising campaign.
    - How will you know that your students are staying on track during the activity?
    - How will you evaluate that students have accomplished the goals at the end and how will you determine how much each person contributed?
3. **Length:**
    - How long will it take to master these goals?
4. **Build a story:**
    - Relate it closely to the goals listed on the first page. Great stories are found daily in the New York Times, New Scientist, Discover Magazine, Local Store. The more socially relevant to your student population, the more interesting they will find it.
5. **Activities:**
    - Using the assessments you wrote down in # 2 on the previous page, come up with some activities and assignments you can use for you case. Make sure the students are doing something other than just listening to you talk.
    - Do you want all the information released at the beginning, or in stages?
    - Who is the voice in your story? Will there be dialog?

6. **Write down teaching notes so that the TAs or another instructor can use your brilliant ideas.**

Web Links:

- National Center for Case Studies in Teaching: http://ublib.buffalo.edu/libraries/projects/cases/case.html
- Case It!: http://caseit.uwrf.edu/
- Several participants expressed interest in learning more about the Biology Concept Inventory (BCI), which they used to help develop the learning goals for their cases. More information about the BCI and can be found at: http://bioliteracy.net/