Unraveling complexity: building an understanding of Everglades restoration

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Understanding the complexity of ecosystems at all scales, macro to micro, is challenging for students (and scientists!) to unravel. Sklar and colleagues present the engaging problem of the restoration of the Florida Everglades (pp 161–169), including history, biology, hydrology, modeling, and regulatory morasses. Students need to learn how to derive and interconnect biological concepts from the literature as well as from textbooks. To do so they must connect new information with prior knowledge to make sense of the ideas and concepts presented. In this article, we model a way to guide and assess students' understanding of the biological principles featured in Sklar *et al.* before they come to class. Instructors use this formative assessment to modify classroom instruction, and to assess students' understanding of those principles at the end of class.

Student goals

- Read a complex article, derive and interconnect the biological concepts to construct understanding.
- Build models that predict how abiotic and biotic factors interact in complex systems.

Instructor goals

- Implement Just-in-Time Teaching (JiTT) instructional strategies.
- Analyze and use formative data from students' responses to their reading before class to guide instruction in class.
- Develop summative assessments that quantify and elucidate students' understanding of complex ecological problems and demonstrate their ability to synthesize information.

Before class

With the increased availability of classroom management software, such as Blackboard (www.blackboard.com), Web CT (www.webct.com), and Lon-Capa (www.lon-capa.org), faculty are using pre-class assessments designed to motivate students to read materials as well as to check their understanding. Many discussions among instructors using these systems focus mainly on how to prevent students from merely getting the correct answer from their peers. Here we introduce JiTT as a method for using pre-class assessments to help students connect new information to their prior knowledge, thereby deepening their understanding (Novak *et al.* 1999; Marrs and Novak 2004). Faculty can assess their students' competencies and modify class content accordingly.

In the JiTT model, students respond electronically to web-based assignments due shortly before class (a day or a few hours), and the instructor reads the student submissions to adjust the lesson to respond to students' replies. A goal of JiTT, or any active learning inside or outside class, is to engage students, promote more and high quality student–student interactions, faculty–student interactions, and students' study time. The example we present using JiTT and the Sklar *et al.* paper is not intended to stand alone in a course. Both students and faculty need to practice this type of instructional innovation to maximize its benefits. The data that faculty collect with JiTT can be used to measure improvements in students' understanding.

Before class, Sklar *et al.* is assigned as reading material. Warm-up questions in Panel 1 appear online and are designed to address students' prior knowledge about the ecological concepts fundamental to restoration of the Everglades and determine their understanding of the reading.

During class

Student responses from the warm-up assignment contribute to the content of the class and serve as an engagement tool. A mini-lecture based on the responses (10–15 minutes) can be used to clarify new biological jargon, begin to address

Panel 1. Warm-up questions

- Describe the differences in the appearance of the Everglades landscape today, compared with what it must have been like in the 1880s.
- The Comprehensive Everglades Restoration Plan wants to reverse the negative environmental trends by "getting the water right". Based on your understanding of the situation, what is "wrong" with the water now?

Instructors may provide additional web sources or references that allow students to explore material that supports the warm-up questions and provides information about new jargon and concepts. For this example, the website presented in Sklar *et al.* provides a good starting place (www.evergladesplan.org).

Students send their responses to the questions electronically to the instructor, who sees what students know about the topic and understand from the reading. Instructors use the rubric below to sort out the trends in responses.

- Unclear or unrelated information
- Accurate but incomplete response
- Accurate response but shows no interconnections of concepts
- Accurate response and demonstrates interconnections of concepts

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Panel 2. Assessment: group answers to a question

Building canals and water control structures to drain the soils for agriculture and urban use and to control flooding has altered water flow in the Everglades. For each of the items below explain, in one sentence, how each has been influenced by these activities.

- Water table
- Salt water intrusion into aquifers and well fields
- Marsh distribution
- Soil
- Water flowing to the Gulf of Mexico
- Phosphorus loads

Panel 3. Assessment: synthesis of biological concepts in a model (eg concept map)

How does your item influence:

- Tree islands?
- Cattails?
- Calcareous periphyton?
- Species of algae associated with eutrophication?
- Sea grass beds in the Gulf of Mexico?
- Alligator populations?

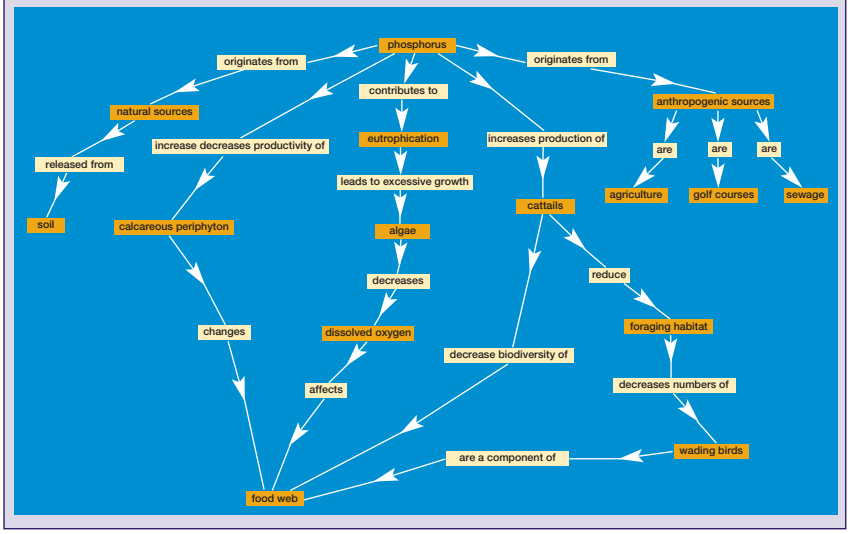
What are the biological consequences of this influence?

alternate conceptions students may have about the content, introduce new content, and help students build connections between the concepts and their own experiences. This type of teaching does not mean that faculty cannot plan the class meeting in advance. Student responses to these kinds of pre-class assessments are in many instances predictable and can be planned. Importantly, students see the warm-up as contributing to the direction of the class, thereby increasing their sense of ownership and community in the course. Once the instructor addresses alternative conceptions and clarification of ideas evident from the responses, groups of students prepare answers to the question in Panel 2.

Groups share answers, which are recorded and are used for the assessment in Panel 3. Individuals or groups are then assigned one of the items from Panel 2 to make a model such as a concept map (Williams *et al.* 2004) that explains how the item interacts with the biological factors from Panel 3.

The model in Panel 4 shows the interactions that occur as a result of increased phosphorus loads. This model provides students with a visual tool for sorting out and connecting the components of this ecosystem (drawn with www.ctools.msu.edu). Evaluation of this synthesis problem is based on the accuracy and logic of the connections and hierarchy of the map. Level of performance can be based on the rubric for the warm-up questions.

Panel 4. Impact of phosphorus on the Everglades



Final note

This article models scientific teaching because the process of helping students unravel the complexity of an ecological issue is as important as gaining an understanding of the issue itself. Many researchable questions may arise during this process, as considered in Ebert-May *et al.* (2005). By engaging students before class, using their prior knowledge or that gained from answering the warm-up questions as a basis for some of the class content, and then having them construct models to assess their understanding, instructors can guide students to develop a more complete understanding of a topic. The limited class time instructors have with students can then be used to help students understand more difficult and complex ecological processes and concepts.

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