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Author(s): Ana L. Porzecanski and Adriana Bravo

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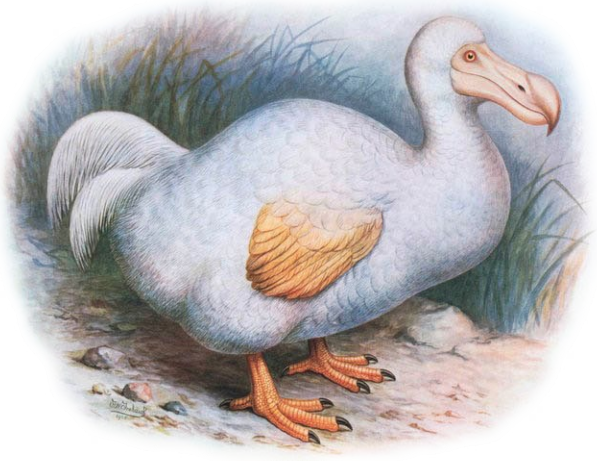

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# What Can Your Students Do? The Importance of Assessing and Developing 21st Century Skills in Conservation Students

Ana L. Porzecanski[1] and Adriana Bravo[2,3]

[1]American Museum of Natural History, New York, NY, USA; [2]The Field Museum, Chicago, IL, USA; [3]The Royal Ontario Museum, Toronto, ON, Canada

## 1. INTRODUCTION

Understanding life on Earth, and how to sustain it, is a fundamental challenge of our time. The task requires professionals and academics who are deeply knowledgeable about the biosphere and its dynamics—a challenge educators rise to meet everyday through courses in environmental sciences and conservation biology. But as educators increasingly adopt evidence-based, scientific approaches to teaching and learning (Handelsman et al. 2004, Freeman et al. 2014, Nordlund 2016), the question arises: what are our courses preparing students to do?

As recent articles and reports have emphasized, educating the next generation of students to address complex societal and environmental issues involves more than the learning of scientific content (NRC 2003, Rhodes 2010, AAAS 2011, Blickley et al. 2013). Intellectual and practical skills—often referred to as professional, "21st Century," or process skills—are considered to be part of the essential learning outcomes of a liberal arts education (AAC&U 2007). It is critical to ensure that undergraduate students develop effective process skills in leadership, communication, working in groups, critical thinking, data analysis, and project management to be effective professionals in conservation science, policy, and practice (Blickley et al. 2013). Yet there is concern that many undergraduate science students in the United States are not currently developing important process skills needed by professionals (Arum and Roksa 2010, NRC 2009, Pascarella et al. 2011).

How can we best teach process skills, and how can we evaluate the development of these skills in our students? The materials featured in this issue of *Lessons in Conservation* formed the basis of a recent study led by the Network of Conservation Educators and Practitioners (NCEP) to answer these questions. The aim of this editorial is to familiarize readers with how the materials were used in the context of this study, and discuss the findings as well as implications for conservation education.

## 2. STUDY BACKGROUND AND DESIGN

The Network of Conservation Educators and Practitioners project (ncep.amnh.org) develops and disseminates open-access teaching and learning materials to enhance and broaden access to conservation education and training worldwide. NCEP materials, or modules, are multi-component, peer-reviewed, and adaptable. They are design to provide students the opportunity to learn and apply new content knowledge, and develop process skills. Once a critical mass of NCEP modules was available, NCEP partnered with module users to begin to evaluate their effectiveness, starting with knowledge gains. A series of faculty-driven studies demonstrated that NCEP modules can help faculty members improve student content knowledge, student confidence in knowledge, and student interest in biodiversity topics (Hagenbuch et al. 2009).

In 2010, NCEP initiated a new study[1] designed to investigate skill development associated with module use. The study brought together NCEP investigators and faculty participants from diverse institutions to explore how to best operationalize the teaching and assessment of skills in Conservation Biology and other integrative fields. The study selected three focal skills for investigation—oral communication, data analysis, and critical thinking—and built on several existing NCEP modules.

The study targeted five key questions:

1. By using the instructional materials, did students

[1] NSF DUE-0942789, *Developing and assessing process skills in Conservation Biology and other integrative fields.*

improve their abilities, in relation to the targeted process skills?
2. Did student confidence in their abilities change, in relation to a particular skill?
3. Did individual students accurately diagnose their own level of development, in relation to the targeted skill?
4. Were changes in process skills performance correlated with content-related performance?
5. And finally, was the intensity of the teaching intervention correlated with the overall gains in process skills in the classroom?

Materials were developed so that students would complete exercises practicing the target skill (either oral communication, data analysis, or critical thinking) twice during the term of a given course, and be exposed to either a "light" or "intensive" teaching session (an "intervention") focused on the skill between the two exercises. In a second iteration of the course (second term), the same exercises—but a different intervention—were used (see Figure 1).

Light interventions were designed to reinforce students' development of skills while keeping the intervention from the professors to a minimal level. Here students received their graded rubric from the first exercise (Exercise 1) and if questions arose, professors answered them keeping the total discussion to no more than 10 minutes. At the end of this discussion, professors reminded students that the same rubric would be used to evaluate their performance for Exercise 2. On the other hand, intensive teaching interventions also involved receiving feedback on Exercise 1, but there were opportunities for a deeper study of the skill over a full class period, and promoted deeper engagement with

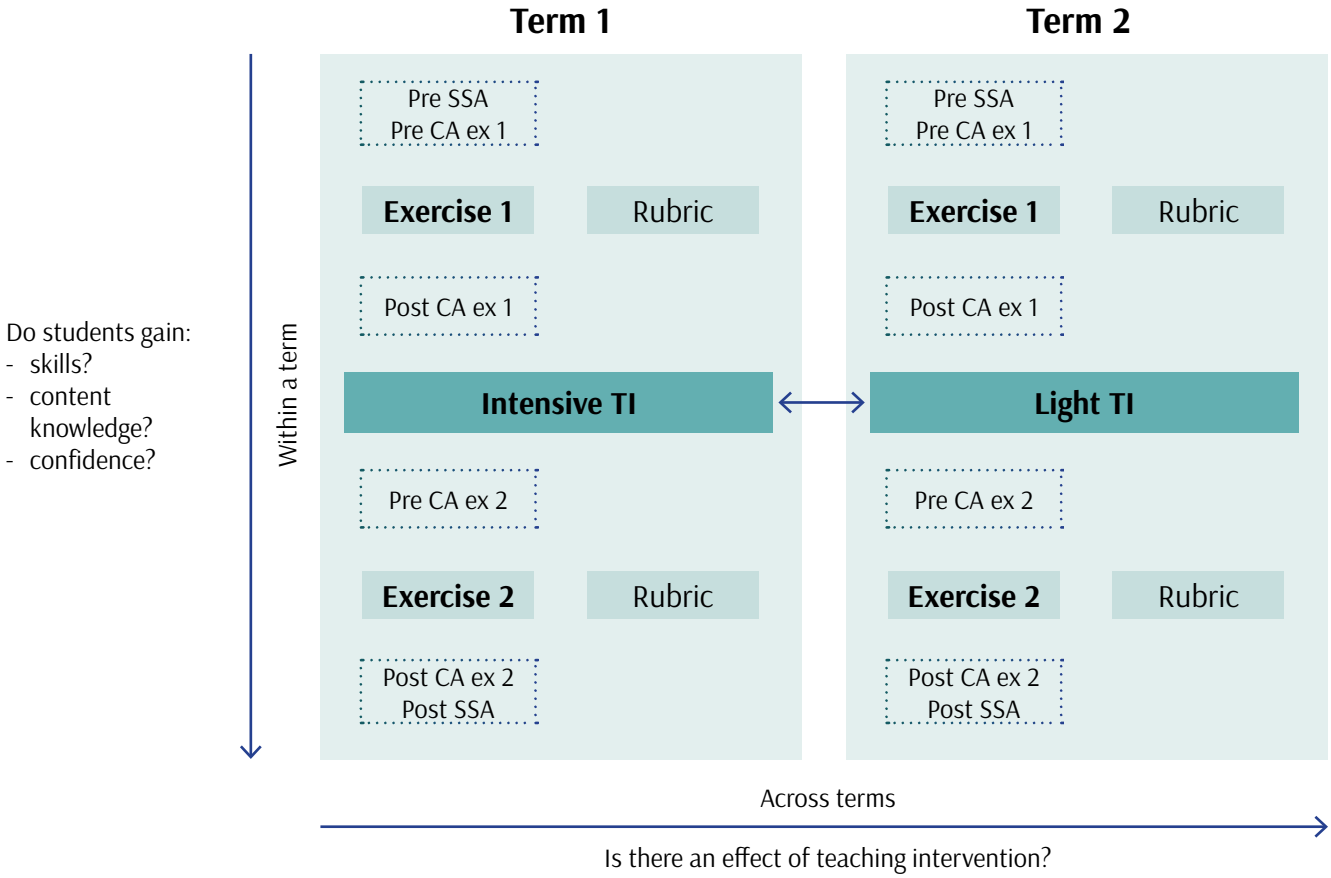


*Figure 1. Experimental design and main questions within and across terms. For each target skill, two exercises were used over the course of a term (details in Table 1). The double-sided arrow between light and intensive teaching interventions (TI) indicates an interchangeable order. Abbreviations are as follow: SSA = student self-assessment; CA = content assessment; ex 1 = exercise 1; ex 2 = exercise 2; and TI = teaching intervention.*

the rubric as well as self-reflection. A summary of the exercise topics and intensive interventions is provided in Table 1.

Each final set of materials consisted of:

- *Two analogous exercises* designed to promote development of the target skill, with exercise solutions.
- *A rubric* to grade exercise results and score skill level after each exercise. The rubric for each target skill typically encompassed between four and six dimensions, or criteria, with which to assess performance.
- *Pre/post content assessment questionnaires* for each exercise, each consisting of 6–7 multiple-choice questions and three open-answer questions, to assess gains in content knowledge.
- *Pre/post self-assessment questionnaires* for the target skill, with 5–6 questions to assess student attitudes towards the skill, and their perception of proficiency and confidence related to that skill.
- *Instructions for teachers* on how to lead a light and an intensive teaching intervention targeting the skill.

The study design meant that each participating instructor would have to collect data on skill performance, content gains, and confidence gains from individual students during two terms, plus lead either a light or intensive teaching intervention mid-term. Hence, a priority for the research team was to develop materials that could be easily integrated into existing courses, instead of materials that would require major course restructuring or redesign. We strived to maintain a workload for preparation, application, and data collection that would be considered feasible by the instructors.

## 3. STUDY FINDINGS

The study convened and fostered a productive, rich, learning community of diverse faculty members from

*Table 1. Exercises and intensive interventions used in the study, for each target skill.*

| | ORAL COMMUNICATION | DATA ANALYSIS | CRITICAL THINKING |
|---|---|---|---|
| **Exercise 1** | *Why is biodiversity important? An oral communication exercise* | *Parrots and palms: analyzing data to determine best management strategies and sustainable harvest levels* | *Applying critical thinking to the amphibian decline problem* |
| **Intensive teaching intervention** | *Sharpen your oral communication skills!* Students use the same rubric they received from Exercise 1 to score an oral presentation by another student (video from a conference) and reflect on the video of the five minute oral presentation they prepared and delivered as part of Exercise 1. They are also handed out tips for their second presentation. | *Practice your data analysis skills!* Students use the same rubric they received from Exercise 1 to score the data analysis performed by a hypothetical student on a small dataset on nest parasitism by brown cowbirds on songbirds (adapted from a published study), and discuss ways to improve the responses. | *Overexploitation of parrots in the Neotropics*[a] Students use the same rubric they received from Exercise 1 to score the critical thinking of a hypothetical student responding to questions on a case study on the overexploitation of parrots in the Neotropics, and discuss ways to improve the responses. |
| **Exercise 2** | *Selecting areas for conservation: an oral communication exercise* | *What is biodiversity? Analyzing data to compare and conserve spider communities* | *Applying critical thinking to an invasive species problem* |

[a]This teaching intervention was previously published in the July 2014 issue of *Lessons in Conservation*.

17 institutions across the United States, the US Virgin Islands, and Puerto Rico. This team collaborated closely on educational research over more than two years, and collected data on 976 students (with IRB approvals). A majority of the faculty participants were highly engaged in data interpretation and reflection on the implications for their own teaching, making this a highly collaborative project with high faculty development value. A summary of the study's main findings can be found in Box 1 and Table 2 and key results are described below. Detailed descriptions of the study results have also been published recently (Bravo et al. 2016, Sterling et al. 2016, Porzecanski et al. in prep).

*Students can measurably improve in key process skills in one term by practicing with exercises.* Average student performance gains were positive for all skills ranging from 29 to 40 percent (see Table 2). Gains varied among the different dimensions of a given skill (results not shown). This suggests some aspects of these skills are more challenging than others, or more amenable to development over a single course. The more challenging dimensions, such as, in critical thinking, *the ability to make judgments and reach a position, drawing appropriate conclusions based on the available information,* likely need different attention and may be more efficiently targeted through different activities than those used in this study (e.g., longer-term or more intensive learning activities).

*Students gain knowledge in core concepts after exercises.* Observed average gains in content were between 12 and 31 percent, an important indication that it is possible to target and develop skills in students without sacrificing content gains.

*Students often gain in confidence but these show no correlation to changes in skill.* While we observed significant gains in some dimensions of self-reported confidence along with practice and teaching interventions, these did not mirror the changes observed in skill performance, indicating that adequately diagnosing their own level of skill is challenging for students.

***Box 1. Answers to the five targeted key questions.***

1. **By using the instructional materials, did students improve their abilities in relation to the targeted process skills?**
   Yes, students can improve their abilities in relation to the target skills through the use of the instructional materials.
2. **Did student confidence in their abilities change, in relation to a particular skill?**
   Yes, students also change in terms of their confidence with these skills, however....
3. **Did individual students accurately diagnose their own level of development in relation to the targeted skill?**
   They do not always accurately diagnose their own level of development with the skill, such that performance and confidence are not overall positively related.
4. **Were changes in process skills performance correlated with content-related performance?**
   Yes, students can gain in content knowledge as they gain in skill.
5. **And finally, was the intensity of the teaching intervention correlated with the overall gains in process skills in the classroom?**
   Yes, the intensity of the teaching intervention can affect the overall gains in process skills in the classroom in some instances, but not always.

*Table 2. Maximum mean gains in skill performance and content knowledge observed over the course of a term in the study, regardless of intervention type, for each target skill.* Normalized change (c) is the ratio of the observed change to the total possible change, Marx and Cummings (2007).

| | ORAL COMMUNICATION | DATA ANALYSIS | CRITICAL THINKING |
|---|---|---|---|
| **Maximum mean gains in skill performance** | c = 0.40 ± 0.03 SE | c = 0.29 ± 0.03 SE | c = 0.34 ± 0.04 SE |
| **Maximum mean gains in content knowledge** | c = 0.31 ± 0.03 SE | c = 0.12 ± 0.02 SE | c = 0.21 ± 0.04 SE |

*The intensity of the teaching intervention can increase gains for some skills.* We found that the intensive teaching interventions increased average gains from 20 to 40 percent in the oral communication exercises (see Sterling et al. 2016). The teaching intervention involved students watching videos of their initial short oral presentations, and completing homework that promoted self-reflection on the skill. Faculty participating in the study hypothesized that the intense self-reflection required of students was one important factor in the gains. For critical thinking, a higher proportion of students improved their performance under the intensive teaching intervention, although these gains were not statistically significant (Porzecanski et al. in prep).

Finally, we observed that levels of starting student performance greatly varied among institutions and class level, and that some exercises work better with upper-level students.

## 4. IMPLICATIONS FOR TEACHING

For educators wishing to foster skills in their undergraduate students, there are several key take-aways from this study:

We encourage educators to integrate the practice of key skills with course content. While some activities will be dedicated to skill practice, not content acquisition, the results demonstrate that it is possible to target skills without sacrificing content knowledge gains. Case study-based exercises can be a useful tool for this integration, as they provide opportunities to analyze real world data or scenarios, think critically about complex issues, as well as research, synthesize, and communicate new information, all in the context of conservation topics and concepts.

We recommend educators provide opportunities for students to practice a given skill multiple times over the course of a term, and to reflect in between these instances of practice. In this study, the process of practicing, receiving feedback, reflecting on that feedback, and trying again, was beneficial to skill development.

Finally, we encourage educators to approach their teaching with an experimental lens. We hope the materials in this issue of *Lessons in Conservation* will provide a useful example or starting point. While the materials were used in sets and as tools to collect data on student performance during the study, educators can use them simply as exercises, together or independently, and adapt them as desired to the context of their courses, using the editable versions available through the NCEP module collection.

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