Education as a tool for addressing the extinction crisis: Moving students from understanding to action

Lucas Moyer-Horner[1], Rebecca Kirby[2] & Christopher Vaughan[3,4,5]

1. Department of Zoology, University of Wisconsin-Madison, Madison, WI 53706, USA; lrmoyerh@wisc.edu
2. Nelson Institute for Environmental Studies, University of Wisconsin-Madison, Madison, WI 53706, USA; rebeccakirby@wisc.edu
3. Department of Forest and Wildlife Ecology, University of Wisconsin-Madison, Madison, WI 53706, USA; cvaughan@wisc.edu
4. International Institute for Wildlife Conservation and Management, Universidad Nacional, Costa Rica
5. Associated Colleges of the Midwest, San Pedro, Costa Rica; cvaughan@acm.or.cr

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Abstract: Human activity is leading to mass species extinctions worldwide. Conservation biology (CB) courses, taught worldwide at universities, typically focus on the proximal causes of extinction without teaching students how to respond to this crisis. The Extinction of Species 360 course has been taught yearly each fall semester to several hundred students at the University of Wisconsin-Madison for over two decades. In 2007 the instructor and five teaching assistants combined principles driving extinctions, based on traditional lectures and discussion sections, with action-oriented education targeting individual consumer habits, to a group of 285 students. Students learn the science underpinning conservation efforts, as evidenced by highly significant learning (<.001) gains in a 22 question survey in every measured category, and also make direct and immediate changes in their lifestyle and consumption habits. This course succeeded in each of its three primary goals: a) informed students about the value of and threats to biodiversity, similar to traditional CB courses, b) emphasized our personal role (as consumers) in perpetuating the extinction crisis and c) facilitated activities to reduce our impact and help alleviate the crisis. The results suggested students learned CB concepts and understood biodiversity's value, increased their awareness of the connection between personal consumption and extinction, and reduced their collective ecological footprints. Furthermore, students complemented their learning and multiplied the potential for consumption reduction, by participating in action-based activities. Such academic courses can provide a rigorous treatment of the direct and indirect causes of extinction while developing a student's sense of personal empowerment to help slow the extinction crisis. Rev. Biol. Trop. 58 (4): 1115-1126. Epub 2010 December 01.

Key Words: action, conservation biology, consumption, environmental education, extinction.

"The one on-going process that will take millions of years
to correct is the loss of genetic and species diversity
by the destruction of natural habitats.
This is the folly that our descendants are least likely to forgive us."
E.O. Wilson (1980)

We are currently in the 6th mass extinction (Leakey & Lewin 1995), unique in being primarily due to human activity. An ever-expanding human population and attendant rising levels of material consumption have led to human domination of Earth's ecosystems, now extending beyond the biosphere's ability to regenerate itself (Vitousek *et al*. 1997, Wackernagel *et al*. 2002). Tens of thousands of species will likely become extinct in the coming

decades (MEA 2005), driven directly and indirectly by resource consumption (Thomas *et al*. 2004, Daly *et al*. 2007; Fig. 1). Unsustainable resource consumption is driven in developed countries by the "consumer culture" (Elgin 1993, Myers & Kent 2004). To address the extinction crisis, educators must clarify connections between our actions and biodiversity and employ methods that encourage students to reflect on their values, and become self-directed, life-long learners.

To achieve species and ecosystem protection, conservation education must move beyond purely descriptive and reductionist methods to include our interdependence with biological systems (Lovelock 2000) and examination of personal consumption patterns (Jacobson *et al*. 2006). Many individuals fail to recognize how consumption influences species extinctions and ecosystem depletion (Gigliotti 1994, Blumstein & Saylan 2007). Assigning monetary value to the goods and services we extract from the environment is one strategy (Bulte & van Kooten 2000, Trauger *et al*. 2003). However, students can learn intrinsic valuation of biodiversity (Agar 2001) if encouraged to reflect on their relationship with nature. This helps them understand they can diminish the extinction crisis by, for example, reducing greenhouse gas emissions, energy and water use, solid waste production and consumption of high-input foods (Ehrlich & Goulder 2007; Fig. 1).

Conservation education practices have evolved in parallel with increased public concern for environmental issues (Tilbury 1995, Brewer 2001). However, amelioration of the extinction crisis may require reappraisal of educational goals and assessment methods. Learning should be … "the acquisition of knowledge and understanding, the development of skills, and the ensuing changes in affect or behavior" (Handelsman *et al*. 2007). Formal instruction usually stresses diverse forms of *learning*, represented by Bloom's Taxonomy as a hierarchical intellectual framework (Bloom & Krathwohl 1956, Anderson & Krathwohl 2001; Table 1). While useful for curriculum development and goal/assessment alignment (Phillips *et al*. 2008), this framework lacks *action* beyond the classroom. Environmental educators should utilize action-oriented activities encouraging student behavioral changes that alleviate the extinction crisis by actively promoting reduction of consumption and dissemination of this urgent message to the public.

Action-oriented activities are beneficial to conservation education because they can involve all four ways we learn: 1) social

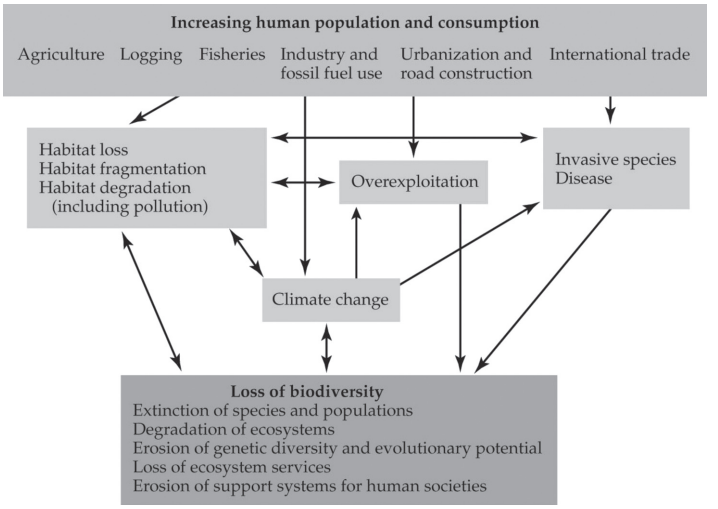

Fig. 1. Model of humanity's direct and indirect effects on Earth's systems and subsequent biodiversity loss (from Primack 2008).

interaction, 2) processing symbolic information (e.g. verbal), 3) direct experience, and 4) reflection (Bolhuis 2003). Traditional courses often focus on the second, but not the other three. However, integration of all four can encourage life-long learning by fostering self-regulation (Slavin 1995), uncertainty tolerance (Huber & Roth 1999), and knowledge transfer (Bolhuis 2003). Conservation action-oriented activities can increase student learning, retention, and action (Eames *et al*. 2006), and benefit the growing population with few prior experiences in nature (Louv 2005).

Like many traditional CB courses, the Extinction of Species course (ES360) at the University of Wisconsin-Madison was originally designed to educate students on the definition of biodiversity, its values and threats, as well as conservation efforts surrounding it. This study reports on our efforts to reorganize the course to include the above and emphasize our *personal role* (as consumers) in contributing to the extinction crisis and facilitate development of activities to reduce our impacts and help ameliorate the crisis.

METHODS

Teaching methods: To introduce the extinction crisis and its relationship with consumption habits, we employed both traditional teaching methods and action-oriented activities (Table 2). We define 'action-oriented' activities as those that were hands-on, reflective and took place outside the classroom.

Action-oriented activities: Students spent four hours in a natural area, meditating and practicing mindfulness, defined as "paying full attention to the present moment" (Burch 2000). This allowed students to reflect on their relationship with nature.

A second project in Environmental Extension involved students presenting a PowerPoint lecture on consumption and extinction of species (WWI 2004) to 30 people, and afterwards reflecting on the experience.

Students tracked their "ecological footprint" (Wackernagel *et al*. 2002) in Environmental Action (EnAct) teams. EnAct was developed by Madison Environmental Group, Inc. (www.madisonenvironmental.com). Students and instructors formed teams of 4-7 people, tracked and reduced their consumption, and communicated with peers about the experience. Each participant completed action reports (www.enactwi.org), during the 2nd and 17th weeks, quantifying individual or household: solid waste production, energy use, water use, transportation, and food choices. Teams used

TABLE 1
Highest-order placement of ES360 assessments within Bloom's Taxonomy, to which "Act" has been added (Adapted from Anderson & Krathwohl, 2001)

	Cognitive Process Dimension						
Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create	Act
Factual Knowledge							
Conceptual Knowledge		Exam, Discussion Quizzes		Extra Credit-Media Report			
Procedural Knowledge					Discussion Participation & Attendance	Research Paper	Extra Credit-volunteer & mug-use
Metacognitive Knowledge					Mindfulness Exercise		Lecture Quizzes, EnAct, Environmental Extension.

TABLE 2
Course ES360 activities, goals and assessments, UW-Madison, 2007

Activity	Learning/Action Goals	Assessments
Lecture	Students will: 1. Understand CB concepts & case studies in extinction research 2. Think and write about their personal relationship with the environment	1. Exam and research paper 2. Lecture quizzes
Weekly Readings	1. Understand modern CB perspectives and the human role in the extinction crisis	1. Discussion quizzes, exam and research paper
Discussion Sections	1. Broaden understanding of extinction and its drivers 2. Engage each other in problem-solving, using CB techniques	1. Discussion quizzes 2. Participation and attendance
Research Paper	1. Produce an original evaluation of a recovery plan.	1. Topic selection, outline, first draft, and final draft
Mindfulness Exercise	1. Reflect on their impact on nature	1. Reaction paper
Environmental Extension	1. Disseminate information and gain awareness of public understanding of extinction crisis	1. Signature form and summary of experience
EnAct	1. Take actions in their daily lives to reduce their environmental impact and that of households 2. Understand the impacts of household activities and lifestyle practices 3. Be aware of local environmental issues 4. Be aware of local resources to facilitate sustainable living 5. Create stronger communities by encouraging neighbors (and colleagues) to communicate and cooperate on reducing ecological footprint.	1. Ecological footprint measurement 2-5. EnAct journal, meeting leader report, team presentation, and team evaluation
Extra Credit	1. Participate in biodiversity conservation. 2. Understand how to access biodiversity information in popular media outlets 3. Be aware and reduce use of disposable items.	1. Supervisor verification and written reflection on experience 2. Written reflection on information 3. Bottle-use tally and written reflection

the EnAct Participant Guide (www.enactwi.org) for information about the community's consumption and strategies for reduction during biweekly meetings outside class. Each student kept a weekly journal documenting the experience and led one team meeting. Sustainability-themed prizes were donated by local businesses and presented to groups with smallest average impacts in each category and to groups with greatest improvements. Students learned that cooperation within groups was a valuable tool to have in promoting a sustainable relationship with nature.

Students could increase their final course grade by 6% by combining portions of three Extra Credit activities: 1) Students could volunteer at an approved conservation-based activity for eight hours (e.g. restoration with the UW Arboretum) and gain first-hand experience of course issues while conserving biodiversity; 2) Students could read approved books, scan websites, and watch movies

relevant to course content and reflect on these (media search); 3) Students could reduce use of disposable drink containers by tracking their use of a mug or water bottle outside of home at least 75 times/semester.

Traditional teaching methods: Lecture was held 3 days/week by the instructor and several invited speakers. Lecture focused on conservation biology principles including: i) biodiversity value and threats, ii) extinction, iii) conserving populations and species, iv) conservation inside and outside protected areas, and v) sustainable development (from World Watch Institute 2004), as well as themes of mindfulness and our place in nature. Lecture goals included understanding CB concepts and case studies in extinction research. We also required students to think and write about their personal relationship with the environment.

Required weekly discussion sections of 18-21 students provided student-centered learning, with a teaching assistant facilitator. They were based on assigned weekly readings from peer-reviewed articles and three required texts: i) Primack (2004), ii) Burch (2000) and iii) Diamond (2005). Activities included presentations, role playing, small group discussion, case studies, and debates.

Students also undertook a research paper requiring an eight-page science-based critique of an endangered species' current situation utilizing peer-reviewed literature. The scientific paper format included formative feedback on: a) species selection, b) outline with thesis statement, c) first draft and d) final product.

Assessment methods: We designed course assessments to identify higher-order learning and cognitive processes. In-class learning assessments typical of other CB courses fit within the Bloom's revised taxonomy framework; however our action goals that emphasized taking an active role to lessen the extinction crisis necessitated adding an extra column, "Act" (Table 1). Surveys and action reports measured both in-class learning gains and conservation action. We describe grading procedures below, but do not report grades as they tend to be subjective and their assignment varies significantly between institutions.

We assessed action-based activities on a participatory level, with corresponding written assignments and presentations (Table 2). We assessed both the mindfulness exercise and Environmental Extension project with student one-two page reflections on the experiences (and audience signatures for Environmental Extension). We measured EnAct-mediated consumption reductions by comparing initial baseline reports to end-of-semester reports. This reduction rate was extrapolated to an equivalent 1-yr rate. We regularly evaluated student participation in EnAct through individual action journals, team leader reports, and end-of-semester team presentations and team self-evaluations. We evaluated Extra Credit through student written reports (and supervisor verification for volunteering) or by submission of a dated list for mug-use.

We measured in-class learning using assessments listed in Table 2 and described here. Two one-two page in-class essays quizzes gave students an option of two or three content-oriented questions. A mid-term exam consisted of multiple choice, fill-in-the-blank and short answer questions drawn from lecture content and readings. Discussion quizzes focused on readings and activities. We based participation and attendance grades on quantity and quality of participation in discussion sections. The research paper was graded at each step: outline, draft, and final product.

Surveys: We assessed in-class learning and conservation action through 22 questions answered anonymously by students, administered during both the 2nd and 17th weeks of the fall semester, 2007. These questions, based on course activities and concepts, covered the students' current knowledge, understanding, experience, and desire to act (Appendix A). They were grouped into four sections that covered the EnAct program, environmental extension, research paper, and discussion activities. Students responded to each question with a whole

number on a scale from 1 (strongly disagree) to 5 (strongly agree). We calculated the mean response for each question and performed a t-test (R-statistical package, www.r-project.org) to compare the class means of the second week, to the means of the final week.

RESULTS

Conservation Action: The Environmental Extension activity involved dissemination of information connecting personal consumption and the extinction crisis to 8 500 individuals (285 "teachers" * 30 "students"). Through EnAct, students, their peers and instructors (N=360) used public transportation more frequently, and decreased fossil fuel emissions, miles driven and solid waste produced (Table 3). Extra Credit mug-users refrained from using an estimated 7 500 (N=133 students) disposable beverage containers and 70 students engaged in conservation-based volunteer activity for a minimum of 8hrs each.

Surveys: Class mean levels of agreement with each survey statement increased significantly from before to after the course ($p << 0.01$; pre-class $N \approx 178$, post-class $N \approx 163$; Fig. 2). Sample sizes varied because some statements were left blank.

DISCUSSION

Our activities and associated assessments were designed to both engage higher-order cognitive processes and also to initiate direct conservation action (Table 1). We discuss both in-class learning and conservation action, emphasizing the latter because: i) few courses encourage this, ii) students make direct contributions to biodiversity conservation, and iii) hands-on experiences provide the most effective learning environments (Finger 1991).

In-class learning: Survey results suggested achievement of learning goals. Significant post-class increases in average survey scores suggested students learned lecture and discussion material (Fig. 2, questions Q13-22).

Learning to write a research paper is a valuable college experience. The ES360 research paper was a unique experience for many students, during which they: a) formulated a thesis statement declaring the critical component(s) of their species' endangered status, and b) supported it with evidence from a recovery plan and primary literature. At its conclusion, students reported increased confidence in understanding factors influencing species endangerment and conducting information searches (Fig. 2, Q13,16,17).

Students also learned to evaluate an endangered species' recovery plan (Fig. 2, Q18). Success can be attributed partially to a task-oriented process with multiple deadlines and constructive feedback throughout the semester. Upon course completion, students felt confident they could produce brief conservation plans (Fig. 2, Q14,15) on threatened species, which reflected their understanding of CB principles.

TABLE 3

EnAct program actions. Behavioral changes by students, their peers and instructors in ES360 and the resulting ecological impact over the course of a 17-week semester (N = 360). Values were calculated by comparing baseline consumption surveys (week 1) to results surveys (week 17) and extrapolating to one year

Category	Action
Transportation: public transport	Increased 9570 bus trips/year
Transportation: fossil fuels	Decreased 13,040 gallons gas/year
Transportation: driving	Decreased 324,954 miles driven/year
Solid Waste	Decreased 1251 lbs./year

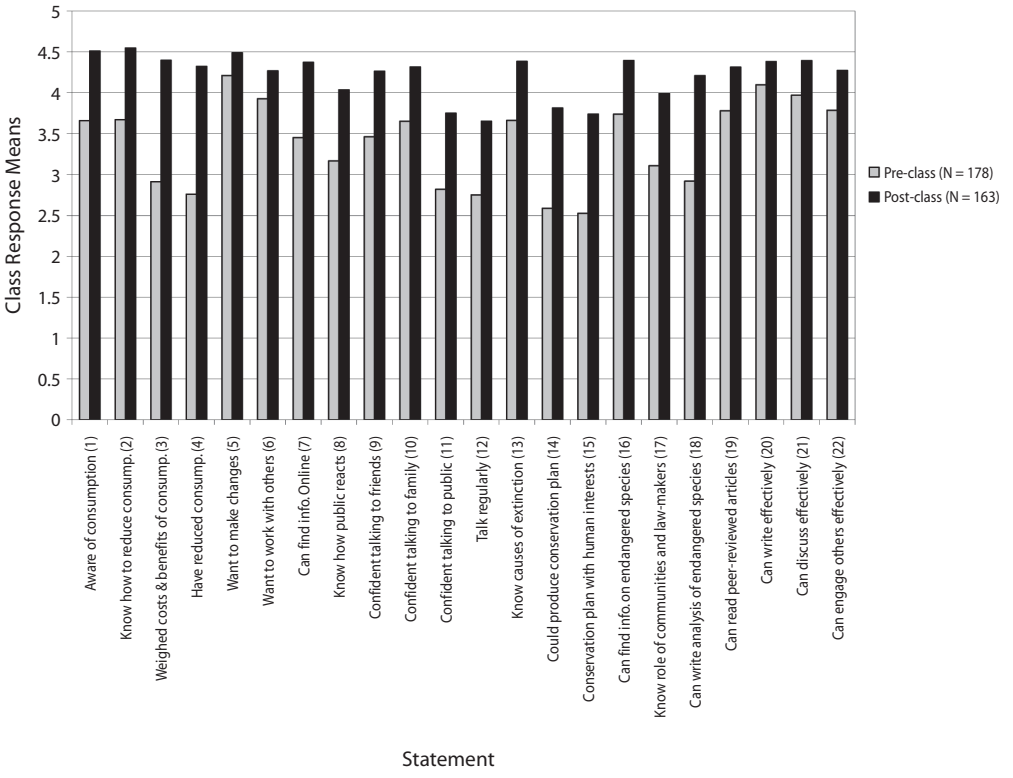

Fig. 2. Survey results. Each statement showed a highly significant increase from pre- to post-class ($p << 0.01$), calculated using the t-test function in R-statistical software. Statement paraphrases appear along the x-axis.

Conservation action

Mindfulness: Commitment to conserve biodiversity by reducing consumption was reinforced by the mindfulness exercise in a natural setting. This encouraged: a) critical reflection on nature and prior knowledge, b) consideration of alternative behaviors, and c) action upon these thoughts. While sitting in the woods, one student wrote: "I began to think about when I was younger and life was simpler. I would stay outside from sunrise to sunset just playing with the neighbors in the woods outside of my house, without a care in the world and the constant struggle and desire for material gain…. This was a huge wake up call for me, as I spent the remainder of the afternoon thinking about how I can change the direction of my life and decided to engage in less materialism and more human relations and free individual activities." This passage exemplifies how mindfulness and simplicity (e.g. consumption reduction) enhance each other through a positive feedback loop (Burch 2000). Critical reflection encourages liberating or transformational learning, following internalization of cultural meaning, often transmitted and imposed by the most powerful in a society (Baumgartner 2001).

Environmental Extension: Rarely are undergraduates assigned a project requiring them to teach classroom information to colleagues. Given the positive results of the Environmental Extension activity, this technique reinforced student learning, retention, communication, and defense of a topic. Students significantly increased their familiarity with environmental

awareness information and communication with family/friends (Fig. 2, Q7-10). Over 70% included relatives among their 30 "students," indicating intergenerational sharing and learning. Many students reported intense discussions on environmental themes such as oil, global warming, extinction, food choices, quality of life, recycling and consumption. Others have found similar attitudinal and behavioral benefits associated with peer (Ballantyne *et al*. 2001) and intergenerational (Vaughan *et al*. 2003) communication of environmental themes.

Participants felt increased confidence in their ability to communicate environmental issues with the public on a regular basis, especially with university colleagues (Fig. 2, Q11,12). They recruited UW colleagues to watch their presentations after classes, in dorms, apartments, or libraries; and even held "parties" where they offered food and drinks. Thus Environmental Extension promoted inter-community learning within the university setting and allowed families a chance to be exposed to and debate current environmental issues. Continuation of these activities among students will promote environmental stewardship as Korsching & Borich (1996) found using multi-community collaborations in rural areas.

EnAct. Regarding consumption reduction, EnAct was a successful activity (Table 3) and similar initiatives should be adopted in classrooms nation-wide to encourage changes in student consumption patterns. Over the 4-month period students produced immediate and quantifiable results.

Before ES360, many students had not made a conscious effort to reduce their ecological impact, nor weighed the costs and benefits of such action. However, afterwards students felt strongly that they deliberately considered the ecological consequences of their actions before making choices (Fig. 2, Q3,4). They exhibited heightened awareness of consumption and how to reduce it (Fig. 2, Q1,2). Importantly, consumption was reduced (Table 3) and each block A statement averaged a post-class response above 4.25 (agree to strongly agree) indicating the EnAct project goals (Table 2) had been met.

EnAct challenged students to change their behaviors and interact with others during the course. Our goal was to create a learning model that connected species and ecosystem protection to personal consumption in an active way, and increase chances of long-term effect. Students set their own team and individual action goals, thereby cooperatively creating their own model for self-directed learning and consumption (Slavin 1995). In addition, we included a critical reflection component (action journals), promoting knowledge transfer between contexts (Volet 1995), such as those encountered outside the classroom. Finally, we encouraged students to adopt an optimistic outlook by highlighting positive contributions they could make (Beever 2000, Orr 2007).

Improvements to EnAct would allow a more accurate "ecological footprint" estimate in more categories. Energy use, water conservation and quality, and food choices were difficult to quantify due to inefficient online survey formats and housing situations facing the majority of the participants (e.g. many students rent shared housing with heat and electric costs included). Even so, students reported significant reductions in these categories as well; however, survey changes would facilitate more accurate tracking. For example, surveys asked students only for an estimate of shower length and whether a water-conserving shower head was installed. If we instead instructed them to measure shower water volume during, for example, a 30s interval it would have allowed them to convert shower times into water volume.

Implementation of a program similar to EnAct in any classroom or community should be preceded by careful consideration of project goals and intended users. For example, one might consider: How quantifiable should the results be? How important are accuracy and precision? How user-friendly is the process? In future work, educators should look to demonstrate long-term student commitment to action (*sensu* Fishbein & Ajzen 1975) using longitudinal studies during school and post-graduation.

Extra Credit: Extra credit activities provided incentives for additional learning and action towards abatement of the extinction crisis. College students often feel overwhelmed by course workloads and do not participate in non-credit activities, so we offered a small grade incentive to encourage involvement. The large number of Extra Credit participants (133/285=47%), especially as volunteers for a minimum of 8hrs (N=70), suggests they understood their personal role in the extinction crisis, committing substantial blocks of time to its reduction. Volunteers contributed directly to biodiversity conservation (e.g. prairie restoration) and/or outreach (e.g. environmental education). Both volunteering and the media search were student-directed activities. Student involvement in goal setting is necessary for motivated and self-regulated learning (Gredler *et al*. 1996). Students were encouraged to explore and conceive of ways to address the extinction crisis, which fosters problem-solving capacity rather than only static concern for competence (Chin *et al*. 1994).

While looking back at the organization, implementation and subsequent analysis of this course, we feel justified in stating that:

1. Courses drawing clear connections between the extinction crisis, global warming, environmental contamination and individual behavior can provide the interdisciplinary breadth, intellectual and social challenges, and personal interest necessary to cause behavioral changes.
2. Community and action-oriented programs can develop a sense of empowerment in students to act to improve our collective chances of decelerating the extinction crisis, which will require individuals committed to action and cooperation on a global scale.
3. ES360 posed significant intellectual and logistical challenges for the instructor and teaching assistants. The large initial investment in time and energy to coordinate a similar course may prove daunting to many teachers. However, we believe this investment will pay invaluable dividends in ecological, economic, social and spiritual capital for future generations. Additionally, this initial investment will decrease as a larger community of instructors adopt new strategies, utilize new technologies, share their work, and make materials available.

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RESUMEN

La actividad humana está produciendo grandes extinciones de especies en todo el mundo. Los cursos de biología de la conservación (BC), impartidos en universidades de todo el mundo, por lo general se enfocan en las causas de la extinción, sin enseñar a los estudiantes cómo responder a esta crisis. Durante más de dos décadas, la Universidad de Wisconsin-Madison ha ofrecido el curso Extinción de las Especies (#360), que se ha dado cada año, durante otoño a varios cientos de estudiantes cada vez. En 2007 el instructor y cinco asistentes de enseñanza combinaron los principios de manejo de la extinción, con base en presentaciones tradicionales y una sección de discusión, con educación con acción-orientada a los hábitos individuales de consumo, a un grupo de 285 estudiantes. Ellos aprendieron que la ciencia sustenta los esfuerzos de conservación, como lo demuestra el aprendizaje altamente significativo (P<.001) en una encuesta de 22 preguntas en todas las categorías medidas, y en cambios directos e inmediatos en su estilo de vida y hábitos de consumo. Este curso tuvo éxito en cada uno de sus tres objetivos principales: a) los estudiantes fueron informados sobre el valor y las amenazas a la biodiversidad, similar a los tradicionales cursos de BC, b) hizo hincapié en nuestro papel personal (como consumidores) en perpetuar la crisis de la extinción y c) facilito actividades para reducir nuestro impacto y ayudar a disminuir la crisis. Los resultados sugieren que los

estudiantes aprendieron conceptos de CB y comprendieron el valor de la biodiversidad, aumentaron su preocupación por la conexión entre el consumo personal y la extinción, y redujeron la huella ecológica colectiva. Además, los estudiantes complementaron su aprendizaje y se multiplicó el potencial de reducción del consumo, mediante la participación en actividades basado en acciones concretos. Estos cursos académicos pueden proporcionar un tratamiento riguroso de las causas directas e indirectas de la extinción, al mismo tiempo que desarrollar en el estudiante el sentido de poder personal para ayudar a disminuir la crisis de la extinción.

Palabras clave: acción, biología de la conservación, consumo, educación ambiental, extinción.

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APPENDIX A

*Survey administered to students in ES360 at beginning and end of the fall 2007 semester. Blocks A-D were designed to evaluate: **A**- EnAct, **B**- Environmental Extension, **C**- Research Paper, and **D**- Discussion Activities*

Please rank each of the following statements using this scale:
1=strongly disagree, 2=disagree, 3=neither agree nor disagree, 4=agree, 5=strongly agree

A:

1. I am aware of the impact of my consumption on the planet
2. I am aware of how to reduce my impact on the planet
3. I have weighed the costs and benefits of reducing my impact
4. I have made efforts to reduce my impact
5. I want to make changes to reduce my impact
6. I want to work with others to reduce our collective impact

B:

7. I know where to find environmental awareness information
8. I understand how the public reacts to environmental awareness information

I am confident in my ability to communicate environmental issues with (9-11):

9. my friends
10. my family
11. the public
12. I communicate with others about environmental awareness on a regular basis

C:

13. I understand the factors influencing the endangerment of many species

I could produce a conservation plan that includes the needs of (14,15):

14. many species
15. many species, including humans
16. I know where to find information on particular endangered species
17. I understand how legislation and community involvement impacts an endangered species
18. I know how to write an analysis of an endangered species and its situation

D:

I am able to:

19. dissect the main points of various peer-reviewed scientific articles
20. communicate my opinions in writing
21. convey my knowledge and opinions in a discussion
22. engage others in a discussion