

Using ‘Evolution for Everyone’ as a Guide for New General Education Courses in Evolution

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ABSTRACT

An introductory evolution course accessible to students from all academic backgrounds is an important component of a multi-course EvoS program. The success of the “Evolution for Everyone” course developed at Binghamton University makes it a useful model and the EvoS consortium can facilitate the development of similar courses at other campuses, while also allowing flexibility for each instructor. In this article we outline five basic ingredients that make such a course work: 1) introducing the basic principles of evolution; 2) broadly applying them to a variety biological and human-related subjects; 3) emphasizing scientific methodology; 4) conducting in-class research; 5) and encouraging students to pursue scientific inquiries of their own. We describe how these goals are accomplished in our “Evolution for Everyone” course and how the infrastructure of the EvoS Consortium can help facilitate them at other institutions.

KEYWORDS

Evolution education; science education; EvoS consortium, Evolution for Everyone, interdisciplinary approaches

The basic mission of an EvoS program is to expand evolutionary theory beyond the biological sciences, to reach as many students as possible early in their academic careers, and to provide a multicourse curriculum so students can continue their training throughout their academic careers. An EvoS program cannot be replicated in a cookie-cutter fashion and must be “locally adapted” to each institution, to use an evolutionary phrase. Nevertheless, most programs will need to

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include an introductory course similar to the “Evolution for Everyone” course that we have developed at Binghamton University (BU).

An important objective of the EvoS consortium is to assist member institutions in establishing “Evolution for Everyone” courses and to coordinate the teaching of courses across campuses. It is important to strike a balance between too much and too little coordination. Most instructors will want to follow their own teaching philosophy, feature their own research expertise, and choose their own reading material. At the same time, instructors have much to learn from each other, for example by creating an inventory of teaching modules or by giving exercises at the same time and sharing the results across campuses, as outlined in more detail below.

We have recently described our “Evolution for Everyone” course in detail, including a rigorous before-and-after assessment using a survey developed by Patricia Hawley for consortium-wide use (O’Brien, Wilson, & Hawley, 2009). This article is designed to facilitate the teaching of “Evolution for Everyone” courses across campuses. Both articles should be read by instructors who contemplate developing their own course.

BASIC INGREDIENTS

We think that most “Evolution for Everyone” courses should have the following basic ingredients, regardless of how they are implemented.

1. Begin by teaching the basic principles of evolution, which can apply to the biological sciences and human-related subjects alike.
2. Show how the basic principles can be applied to a diversity of subject domains, including both the biological sciences and all aspects of humanity.
3. Teach the scientific method and basic statistics, in addition to evolution, as a branch of science.
4. Go beyond lecture mode and actually do science as much as possible, even in a large lecture class.
5. Provide an opportunity for the students to conduct their own inquiry on a topic of their own choice.

We will briefly elaborate on each of these objectives, how we attempt to accomplish them in our course, and how the EvoS consortium can facilitate the objectives in other courses.

1) Presenting the Basic Principles of Evolution

As indicated by the title, “Evolution for Everyone” (hereafter E4E) courses are intended for students from all academic backgrounds, providing an engaging and substantive foundation in evolutionary theory that does not require any specific previous coursework. The goals are to provide basic literacy and to encourage the students to continue their evolutionary training by joining the multi-course EvoS program in parallel with their major. To accomplish these goals, a successful E4E course must present the material in a manner that is not only accessible but

enjoyable to science and non-science majors alike. With respect to basic literacy, every student should leave the course with a grasp of the primary mechanisms and aspects of evolution, noted in the order we teach them at BU: natural selection; sexual selection; genetic drift; descent with modification; basic genetics and genome function; the role of both genotype and environment in determining phenotype; co-evolution of traits within and between species; and multilevel selection.

At BU, E4E is a large (150-200 students) introductory-level course that has no prerequisites and satisfies the social science general education requirement. It is cross-listed by the biology and anthropology departments, reflecting its emphasis on both biological and human-related topics. It is lecture-based owing to its large size, but students also attend a smaller weekly discussion section, each run by an undergraduate teaching assistant recruited from previous classes and working for independent study credits. The discussion sections provide a more acceptable teacher-student ratio and are used for a variety of activities that reinforce the lecture material. In addition, the lecture periods go beyond note-giving and -taking whenever possible, for example by asking at least one thought question that students discuss with their neighbors before returning to whole-class discussion. Additional exercises performed during lecture periods are described in more detail below.

Although an active dynamic is helpful in drawing student interest, the framing of the material must itself be intriguing. Because the mechanisms of evolution are relatively simple in their basic precepts, after providing a short introduction to the day's main topic, an instructor can focus on implications and examples. With a wealth of possibilities available, there is room for flexibility based on the interests of the instructor and the students, including specialized topics that might not otherwise be encountered until a more advanced course on evolution.

We emphasize the generality of evolutionary theory by illustrating each major principle with parallel examples from both biological and human-related literatures. We find this mixing particularly effective. For instance, the quetzal's tail is a classic example of sexual selection illustrating the handicap principle in a nonhuman species (Zahavi & Zahavi, 1999), which can be compared with the use of humor and creativity by human males during courtship (Miller, 2000) or the role of costly signaling in religious ritual (Sosis, 2006). In this fashion, students learn about evolution as a theory that goes beyond the biological sciences from the very beginning.

The text that we use for the first part of the course is *Evolution for Everyone: How Darwin's Theory Can Change the Way We Think About Our Lives* (Wilson 2007), which was written on the basis of teaching the course during the first few years of its development. Because the book was written for a general audience, it can be easily read during the first half of the course and supplemented with more technical material during the lectures. We stress that the book is not required as a first text for the course. Other introductory texts or readings assembled by the instructor can accomplish the first goal of presenting the basic principles of evolution.

2) Broadly Applying Evolutionary Theory

When treated at an appropriate level for a general education course, the basic mechanisms of evolution do not fill an entire semester, leaving ample time to apply them to a variety of separate topics. At BU, we spend just over the first third of the semester on an introduction to evolution, followed by a series of 1-2 week-long *modules* on specific topics from an evolutionary perspective. This modular approach is especially effective at making the point that evolutionary theory consists of a single set of principles that can be applied to an extraordinarily broad range of subjects. It also provides flexibility for instructors to select their own specific topics.

At BU, we always begin with a first module on human evolution, including lectures on primate history, human social adaptations, and cultural evolution, setting the stage for subsequent modules that continue to explore evolution in relation to human affairs. Because the possibilities for specific topics are endless, we also ask the students what *they* would like to learn about from an evolutionary perspective and satisfy their requests to the extent that our expertise allows.

We do not attempt to create modules in a cookie-cutter fashion, but they tend to share a number of features. First, each model is framed as an evolutionary question that can be asked for both humans and nonhuman species, reinforcing the theme that evolution includes but also goes beyond the biological sciences. Second, whenever possible, modules include a non-lecture-based activity, optimally an illustrative experiment that is performed in class, during the discussion sections, or through an online survey, with the students acting as the participants. Within a week of the experiment, the results are incorporated into lecture, as described in more detail below. Third, lectures and activities are supplemented with articles from the primary scientific literature illustrating both human and nonhuman examples. The articles are chosen to be short and clearly-written, making them easily accessible to the students, despite the fact that many come from non-science backgrounds and are encountering evolution for the first time. Table 1 contains a list of modules developed at B.U. and their components. One goal of the EvoS consortium is to develop an inventory of modules that instructors can draw from and to which they can contribute. Another goal of the EvoS consortium is to provide a centralized service for analyzing data from experiments performed in class, especially when they are performed at the same time across campuses, as described in more detail below.

Table 1. Available Modules and Associated Material

	Material Linking Animals and Humans	Experiment(s)	Research Techniques	Statistical Techniques	Papers Assigned
Human Evolution	Primate evolution, Social Behavior, Cultural Evolution	Sequential Prisoner's Dilemma	Economic Games	t-Tests	Richerson and Boyd (2001) (Second half only)
Economics	Optimal Foraging Theory, Hawk-Dove Models elaborated into full market systems	Sequential Prisoner's Dilemma; Games measuring risk, loss and ambiguity aversion (see Burks, Carpenter, Goete, Monaco, and Porter, 2008)	Economic Games	t-Tests	Bshary and Noë (2003)
Mating & Dating	Description of ecological influences on mating systems and relevance to human societal and individual choices	Mating Intelligence Survey (Geher and Kaufman, 2007)	Surveys, Subject Recruitment	Chi-square, Correlation	Garcia and Reiber (2009); Bressler et al. (2006)
Personality and Strategies	Discussion of research in animal personality and how factors relate to the Big 5	Big 5 Mini-Markers ^b (Saucier 1994), Bullying Survey (see Gallup, O'Brien, White, and Wilson, 2009) with Hand-Grip Strength Measurement	Scale Formation	Correlation, Regression	Nettle and Clegg (2006); Leenaars et al. (2008)
Cultural Psychology ^a	A discussion of how group-living animals adopt best strategies for survival.	Hofstede Cultural Values Survey (available at http://stuwww.uvt.nl/~csmeets/~1st-VSM.html)	—	Regression	—
Urban Living ^c	How human behavior is influenced by the structures we build.	'The Photo Study' (O'Brien et al., Unpublished data; contact the authors)	Using the Laboratory	Correlation	—

^a Because it has only been taught as the last module of the semester, the treatment of Cultural Psychology was less thorough as more time was invested in preparation of the final project.

^b A measure of the five primary factors of personality, first described by Thurstone (1934).

^c A truncated mini-module that has often been used as a follow-up to cultural evolution.

3) Emphasizing Scientific Methodology

Evolutionary theory is fully nested within the scientific process, and there is evidence that individuals who fully understand the rules of the scientific process are also more accepting of evolution (Lombrozo et al. 2008; Rutledge & Mitchell 2002; Scharmann & Harris 1992; Woods & Scharmann 2001). In one study, acceptance of evolution in secondary school teachers increased after a workshop that focused on scientific theory and evolution (Scharmann & Harris 1992). Based on these findings, we feel that an E4E course should teach the skills of scientific inquiry alongside the primary theme of evolutionary theory. We do this in a number of ways at BU: through exploratory weekly assignments, in-class experiments, lectures that include scientific methodology and statistics, and readings from the primary literature. Another way that we emphasize this theme is by describing the sections of the course as like the sections of a scientific paper. To our knowledge, we are the first course to employ this technique.

As mentioned above, the course consists of two main phases—the presentation of the mechanisms of evolution, and the broad application of them to a variety of topics—which can be compared to the “introduction” and “methods and results” sections of a scientific paper. This parallel is addressed during lectures, reinforcing both scientific methodology and how it is fully intertwined with evolutionary thought. The “discussion” section of the course is represented by the final project that allows the students to interpret what they have learned, as discussed in more detail below.

In addition to providing the framework for the evolution-oriented curriculum, scientific methodology and statistics are fully incorporated into lectures and assignments. Throughout the course, the students learn the skills appropriate to each step of scientific inquiry. While the mechanisms of evolution are being taught, the skills required to write an introduction to a scientific paper are also discussed. The process of asking a question, doing a background literature search, and formulating hypotheses is illustrated in class, and then re-emphasized through weekly assignments. Conducting experiments as part of the modules enables experimental design and basic statistical methods to be discussed. Thus, every few weeks, the students learn a new skill associated with an experimental study and a new statistical technique that can be used for analysis (see Table 1 for examples).

It might seem surprising that basic statistical training can be included in a course that includes non-science majors. Not only have we succeeded, but the skills that we teach in the context of the course can also be used by the students to critically interpret the validity of statistical claims wherever they are encountered, including the popular media. We believe that the best way to increase statistical literacy among all students is to teach basic statistical procedures, not as a separate course, but within the context of the material they are simultaneously learning, as we do during the “methods & results” section of E4E. Based on responses to multiple choice questions on exams, we can affirm that the average student in the 2008 class came away capable of both interpreting statistical claims and applying statistics to their own projects. Over 80% were able to interpret the meaning of a p -value, properly assessing whether a test implied a significant relationship between two variables. Similarly, 84% accurately distinguished between research designs

appropriate for a *t*-test, correlation or regression (there were two such questions on exams, and 84% responded accurately to each).

4) Research in the Classroom

Performing research in which the students act as both participants and researchers permits our course to have a laboratory component, even with a large class size and without a separate laboratory period. This can occur in the form of simple surveys, or actual experiments that occur during discussion section. Like a standard laboratory section, our experiments give the students first-hand experience with the topics that comprise the curriculum, with the additional intrigue of being on the students themselves. The results that are presented in class allow students to see aspects of their own evolved psychology at work, making it even easier to extend them to other individuals, cultures and societies. These activities also provide an appropriate context for teaching methodological procedures (e.g. survey scale formation) and statistical techniques.

As stated, the students act as more than highly informed participants and become the researchers themselves. In discussion sections they develop their own hypotheses on associations between variables, the best of which are selected and tested in lecture. The hypotheses are not confined to a single activity but can integrate across both surveys and experiments, since the data from all studies are cross-linked with each other and with background information obtained at the beginning of class, using procedures to insure anonymity approved by BU's human subject review board. Thus, students can ask whether individuals from larger or smaller communities (part of the background material collected at the beginning of class) are more likely to punish cheaters in a prisoner's dilemma experiment conducted during one of the lectures, or the relationship between cooperating, cheating, and punishment from the prisoner's dilemma game to personality factors as measured by a survey taken online earlier in the course.

These projects immerse the students in the scientific process and evolutionary interpretations even more than the readings, lectures and other non-lecture based activities. To accomplish this feature of the course, we use a team of undergraduate students drawn from previous classes and working for independent study credits, similar to our team of undergraduate TAs. The research team is trained to become responsible for data entry and cleaning; writing keys that connect variables in data sets to items in surveys; scale calculation in data sets (e.g. creating scores for extraversion from the appropriate items in a personality survey); measuring the internal correlations of scale items with Cronbach's alphas (i.e. reliabilities); descriptive statistics; and simple statistical analyses, including *t*-tests, correlations and regressions. Work is required for the instructor to train the team at the beginning, but then they save work during the rest of the course by quickly analyzing the data gathered during one week to be reported during the next week. Students also realize that becoming a member of the team is an important training opportunity and more students apply than we can accept during any given year.

Just as introductory psychology courses use their students as participants to conduct publishable research, the experimental component of our E4E course affords exceptional research opportunities in addition to its pedagogical value. This

is especially true since the experiments can be interlinked and integrated into the course material more than most introductory psychology courses. Our first publication used data from Fall 2007 to investigate the relationships between aggression, victimization, and mating success in adolescents, finding considerable dimorphism between males and females (Gallup et al., 2009). A second publication currently under review validates Geher and Kaufman's (2007) Mating Intelligence survey by correlating survey responses with self-reported sexual behavior (O'Brien, Geher, Gallup, Garcia, & Kaufman, unpublished data). Also under review are the results of an experiment testing people's ability to perceive the social quality of urban neighborhoods from photographs (O'Brien & Wilson, unpublished data).

Most recently, we involved the students in the design of a study from the ground up. Mating Intelligence (MI) is a new concept developed by Geher and Kaufman (2007), and its assessment is in its infancy. Five components of MI are cross-sex mind-reading, self-deception, mate-deception, courtship display, and either sexual over-estimation (males only) or commitment skepticism (females only). Students were assigned the task of contributing to a new MI scale by writing one survey item for each component for each sex, for a total of ten questions. The research team then refined the survey and obtained approval from the human subject review board. Finally, the students helped to administer the survey by each recruiting five respondents who were not taking the course, resulting in a database of over 400 males and 400 females, which was analyzed and the results reported in class.

Our capacity to integrate teaching and research in our E4E class developed over a period of years and might not be easy for every instructor to duplicate. However, the EvoS consortium makes it possible for courses taught at other campuses to benefit from our infrastructure. In particular, experiments can be conducted across campuses at the same time and the data can be analyzed by our team with little more effort than when we analyze the data for our class alone. Coordination is especially easy when surveys are administered online, which means that a link can be provided to students anywhere in the world and their response can automatically feed into our database, to be analyzed and reported back to each instructor within a week. Thanks to the coordination made possible by the EvoS consortium, it will be possible to conduct pioneering research on a worldwide scale in a way that is equally pioneering with respect to science and evolution pedagogy.

5) A Subject of Their Own

The capstone of our E4E course is a poster session in the style of a scientific conference featuring independent projects that the students develop throughout the course as individuals or small groups. The session is advertised across campus, especially to EvoS students and faculty as a way of welcoming a new cohort into the multi-course program.

Preparation for the independent projects begins at the "Introduction" stage of the course, when students are encouraged to think of a topic that they would particularly like to study, conduct a preliminary literature review, and begin to frame their own hypotheses. The students continue to develop their independent study projects as the modules are being taught. Their poster is expected to include an

introduction (including background literature research and hypotheses), methods for a proposed research project, potential results, and a discussion of the potential outcomes from an evolutionary perspective. It is beyond the scope of the independent study project to actually conduct the research (although some of the more enterprising students make the attempt), but this format reinforces teaching the scientific method in addition to evolutionary theory per se. Comments from students in anonymous class evaluations suggest that they find their projects very engaging and that they appreciate the opportunity to study a topic of *their* choice. Even though they do not actually conduct the research they propose, they are often startled to realize how straightforward scientific inquiry is and how much they enjoy it. The poster session format also provides a social dimension, not only allowing the students to view each other's posters but also to realize that their ideas are potentially interesting to the larger community of EvoS students and faculty that they are welcome to join.

CONCLUSION: HOW THE EvoS CONSORTIUM CAN CONTRIBUTE TO THE DEVELOPMENT OF E4E COURSES ELSEWHERE

BU's E4E course, like BU's EvoS program and the NSF-funded EvoS consortium, might seem dauntingly ambitious. In all cases, however, they represent the incremental development of projects with more modest beginnings. There are many ways to implement the five basic ingredients that we think should comprise an E4E course. Instructors should feel free to improvise, using their own talents and available resources. Moreover, the EvoS consortium can facilitate the development of E4E courses at other campuses in several ways.

First, we think of EvoS as an experiment in academic cultural evolution that uses variation-and-selection procedures to derive new and better practices. We encourage flexibility in the development of E4E courses in part to create *variation* in how the courses are taught. *Selection* can be accomplished by rigorous assessment of the courses uses the standardized survey that has been developed by Patricia Hawley (see O'Brien, Wilson, & Hawley, 2009) and more generally by instructors of E4E courses communicating with each other through the EvoS consortium.

Second, instructors have much to gain from drawing from and contributing to an inventory of modules on specific topics from an evolutionary perspective. The modular approach maximizes the benefits of coordination while also providing maximum flexibility. The modules need not be limited to E4E courses and can become a resource for any course being taught from an evolutionary perspective. We look forward to an inventory of modules becoming one of the most important resources offered by the EvoS consortium.

Third, the opportunity to conduct the same experiments across campuses, with the data fed into a central database to be analyzed and reported back to the students within a week, represents an unparalleled integration of research and teaching on a worldwide scale. We look forward to working with the instructors of other E4E courses to make this vision a reality.

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