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A Planning Tool for Incorporating Backward Design, Active Learning, and Authentic Assessment in the College Classroom

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ABSTRACT

Backward course design is a compelling strategy for achieving results-based, student-centered learning. The backward course-design approach is first to identify student-learning outcomes, then the means of assessing the outcomes, and lastly the classroom activities that would support the learning outcomes. With demonstrated success at improving teaching and learning at K–12 levels, this design approach is receiving increasing attention at the college level. Yet college faculty, who receive comparatively little instruction in course design, may find it challenging to enact the principles of backward course design into day-to-day lecture planning. To help address this challenge, we developed a backward design-inspired lesson planner to assist in restructuring college course periods for more active, learner-centered activities that align with course goals. We describe the planner and its application to a non-majors college biology class, and we share student and instructor perceptions of classroom structure and use of classroom time before and after implementation. Benefits of implementing the backward design planner included enhanced ability to prioritize content delivery to students, better time management in and out of the classroom, improved experience of lecture preparation, more engaged students, and more frequent feedback on student comprehension.

KEYWORDS

Class planner; class-time restructuring; results-based teaching

Introduction

"How can I shift my teaching away from long lectures and towards more student-centered, active learning? And how can I manage this shift in a way that is systematic, intentional, and clearly aligned with course learning goals?" Our consideration of these questions led us, a faculty member and an instructional consultant, to develop a simple planner for applying backward course design in the college classroom. Here, we review the fundamentals of backward course design, explain the planner, and describe our experience applying it to restructure class time in a non-majors biology course. Although our intent in designing and implementing the planner was to shift the use of class time away from instructor lecturing, we acknowledge that traditional lectures can be an efficient and even inspiring way to convey content. The traditional lecture is a relatively passive activity for students, however, and we sought opportunity to actively engage students with course material during class time. Thus, a complementary goal of the planner was to offer authentic ways for students to practice application of knowledge, skills and values in the classroom, promoting more frequent and formative assessments of student learning.

The design of the planner is built on the principles of backward course design, an influential strategy for achieving results-based teaching that emphasizes student acquisition of understanding and skills (Barr & Tagg 1995; Wiggins and McTighe 2005). Backward course design asks instructors to consider first the desired student-learning outcomes, then appropriate assessments of those goals, and finally the activities that would support these outcomes. Teaching tactics of backward course design include active learning strategies, whereby students regularly practice skills in class with immediate instructor feedback, and authentic assessments, in which students demonstrate their knowledge and skills through real-world tasks such as debates, exhibitions, experiments and presentations (as compared to multiple choice tests; Dolan & Collins 2015; Fink 2013; Handelsman et al. 2004; Weimer 2013; Wiggins 1989; Wiggins and McTighe 2005).

Backward course design has most often been applied at K–12 levels, and there is evidence that the theories and framework for course planning underlying backward course design improve how K–12 educators plan and teach their courses. Elementary school educators who participated in a lesson-

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planning seminar framed by backward course design were better able to set learning goals, link goals to learning activities and materials, demonstrate content knowledge, connect knowledge to other disciplines, and employ best teaching practices (Kelting-Gibson 2005). Furthermore, K–12 instructors who implicitly or explicitly embedded hallmarks of backward course design into their courses, such as formative assessment and emphasis on application of concepts, observed substantial gains in student learning outcomes (see review by McTighe and Seif 2003). At the college level, student-centered practices of backward course design foster students' deep learning approaches (Trigwell 2010, Wang et al. 2014) and improve student performance in science courses that have traditionally been content-heavy and lecture-driven (Bauer-Dantoin 2009, Singer et al. 2012, Wood 2009).

In contrast with K–12 educators, who receive systematic and extensive teacher training and support, faculty in higher education receive comparatively little to no direct instruction on course design (Golde & Dore 2001, Wulff et al. 2004). This lack of training is particularly acute in the biological sciences, where growing interdisciplinarity, emerging technologies and the rapid pace of discovery have inspired a national agenda to reduce content coverage and rote memorization in favor of student-centered learning that emphasizes science as process and real-world application of skills and knowledge (AAAS 2011). University and college teaching centers work to counteract this gap with Web resources and events such as workshops and multi-day institutes that help college instructors to put backward course design principles into practice. Furthermore, recent publications attempt to educate science faculty about the theories and process of backward course design (Daugherty 2006, Dolan & Collins 2015, Wood 2009). These resources increase college instructors' knowledge of backward course design principles and regard for learner-centered teaching practices (Baker et al. 2014, Ebert-May et al. 2011, Trigwell 2010).

Still, instructors in higher education might find it challenging to enact the underlying principles of backward course design, which operate at a course level, into day-to-day instruction. Indeed, professional development experiences in backward course design can result in little to no shift in instructors' actual practice toward more learner-centered teaching (Ebert-May et al. 2011). For example, our own use of classroom time in an undergraduate biology course remained dominated by long lectures despite our desire for a more active, learner-centered classroom, and awareness of various active-learning exercises. A summer institute on backward course design, offered by the university teaching center, provided a compelling conceptual framework for active learning and resulted in a clearer set of course learning goals. Yet even armed with this framework and goals, it was difficult to move away from ingrained habits of content-based lecturing. We decided that a basic lesson planner was needed to assist in restructuring course periods for more active, learner-centered activities. To be effective, such activities needed to align efficiently with course learning goals. We therefore developed the planner using the framework of backward course design.

In what follows, we introduce this planner as a tool for college faculty to develop day-to-day activities that align with course goals. We describe its application to a non-majors college biology class and share student and instructor perceptions of classroom structure and use of classroom time before and after implementing the planner. We emphasize that our intention here is not to present a rigorous test of improved student-learning outcomes in response to backward course design. Rather, here we share our experience developing and implementing a planning tool to assist college-level instructors in restructuring class time for more active learning consistent with principles of backward course design and flipped classrooms. We also emphasize that our planner does not replace the backward course design process for overall course development; the identification of course goals, core competencies, and a logical sequence of relevant topics is an essential preliminary step to planning individual course periods. Once these elements of overall course planning are in hand, however, we found that the planner helps to structure course periods to maximize active, student-centered learning.

Overview of the backward design planner

Following the backward design approach to curriculum development (Wiggins and McTighe 2005), our planner separates lesson planning into three design steps: identify desired results, determine acceptable evidence, and plan learning experiences and instruction. This basic design can be adapted to planning out major units of a syllabus (i.e., a series of linked lectures) as well as to the more detailed planning that goes into each individual course period within a unit (Fig. 1). Here, we focus mainly on the planning of individual course periods, although later we provide some brief comments about applying the planner to unit planning.

Design Step	Elements	Description				
Identify desired results	Learning Goals	Specify the knowledge, skills, and/or values that students will acquire.	Knowledge, Skill		Value	
Determine acceptable evidence	Assessment	Specify how students will demonstrate their learning, considering formative vs. summative assessment and authentic context.				
Plan learning experiences and instruction	First Exposure	Identify pre-class homework to introduce basics & prep students for more sophisticated & active learning in class				
			Hook Specify an engaging entry point into the unit or class period	Day or Time 1	Day or Time 2	Day or Time 3
	Activities	Building from the first exposure homework, identify teaching & learning activities to promote the learning goals and enable authentic assessment				
	Student Work	Describe active vs. passive work that students will do				
	Location	Specify where each activity will take place				
	Media & Materials	Specify the types of teaching aids needed for each activity				
Reflection	Critique the learning experiences and instruction in light of the actual results. What worked well versus what would you do differently next time, in terms of student preparation, classroom activities and student work, media and materials, and time management?					

Figure 1. Lesson-planning matrix. May be adapted for a unit or an individual lesson.

Identify desired results

The planner first prompts the instructor to identify their objectives for the course period, in terms of measurable changes in student knowledge, skills, or values. Identifying measurable learning objectives before deciding on class period activities keeps the instruction learner-centered versus the vaguer end result of "content coverage." Learning objectives for a given course period or unit should stem from and support overall course goals and competencies. There are excellent guides on developing meaningful course goals and competencies (Wiggins & McTighe 2005, Fink 2013), and this is not our focus here. We note, however, that we find it useful to distinguish between three complementary types of learning objectives: knowledge, skills, and values. By "knowledge" we refer to the understanding of facts, concepts, and principles. By "skills," we mean the ability to apply understanding to achieve a desired result, including general abilities (e.g., critical thinking, analytical skills, science and information literacy, numeracy, organization, management, and oral and written communication) and abilities that are specific to particular disciplines and professions (e.g., legal, accounting, farming). By "values," we mean forms of affective knowledge, rooted in feeling as much as in intellect, and encompassing concepts of merit, importance, and ethics. Values include a sense of place or sense of connectedness within the human community and the larger environmental system within which human communities are embedded; and an interrelated ethical understanding—a sense of responsibility as members of both human communities and ecosystems (Reynolds 2010).[1]

Determine acceptable evidence

The planner next prompts the instructor to identify the methods that will be used to assess student learning of specific knowledge, skills, or values. Assessments are not just evaluative; they can also support learning (Wiggins 1989). As such, assessments can vary in form, length, and depth, ranging from more formative methods such as minute papers (Angelo and Cross 1993) and verbal reports of group discussions to more summative,

[1] As we have defined it, a sense of place may at first appear specific to ecological or environmental studies, but we argue that it is a component of systems thinking, relevant across disciplines. Every human activity is connected to, interacts with, and has implications for the web of life and the flourishing of human and ecosystems. An awareness of the connectedness of all life is increasingly essential in the "full world" of our 21st Century, where human population and resource consumption are many magnitudes higher than in prior centuries, resulting in plummeting biodiversity, global change, depletion and degradation of resources, and serious risk to human well being (Millennium Ecosystem Assessment 2005). Until this connectedness is universally recognized and respected, the future of the planet will remain at risk. We invite each instructor to identify the essential elements of sense of place for their course.

performance-based evaluation of learning outcomes, such as exams,[2] term papers, and project presentations. Formative assessments are typically appropriate for day-to-day class activities, while summative assessments typically come at midterms, finals, or the end of major units. Identifying the scales and types of assessment early will help to inform and prompt further refinement of the first step of backward design: identify desired results.

Plan learning experiences and instruction

To facilitate planning for active, student-centered learning, the planner divides this final backward design step into six subcategories. The first category focuses instructor attention on before-class student preparation, aka "**First Exposure**," and the remaining five categories relate to planning in-class activities. First Exposure planning involves identifying activities that introduce students to basic concepts and provides opportunities to intellectually engage with course material outside of class time, thus freeing up classroom time for more active learning opportunities (Walvoord & Anderson 2009). Assigned readings and associated writing assignments, such as answering questions or writing responses to the readings, are a common and useful form of first exposure. "Readings" may be conventional printed material (e.g., chapters, articles) or various kinds of alternative texts, such as Web sites, videos, or experiences that engage students with course content (e.g., visiting particular people, places or things; service-learning work).

We found that explicit blocking of class time is critical for curtailing lecturing in favor of a productive variety of activities. We therefore designed this section of the planner's structure to include columns denoting discrete time blocks. We found it useful to start the course period with a five- to ten-minute time block devoted to a "**Hook**," followed by activity blocks of approximately 15–25 minutes in length. A hook can be any engaging entry point into the unit or lesson, such as a compelling question, image, film clip, or timely news article. Hooks establish the relevance and importance of course topics, piquing student interest and motivation for learning.

We included rows for describing the **Activities** for each time block and various details that aid in planning the activities. Ideally, class-time activities promote deeper learning of material; allow students to practice their knowledge, skills, or values; and/or enable assessment. Examples include small-group discussions or creative work (e.g., design work, problem solving, analysis), watching a film clip, conducting a field exercise, peer review of writing, engaging in some form of assessment of learning, and mini-lectures. Service-learning activities can also be fruitfully worked into class time as a means for students to apply their learning. Service learning is a form of experiential learning wherein students complete routine tasks (direct service) or focused creative projects (project-based service) for community partners (Schonemann et al. 2011).

A row for **Student Work** characterizes the class-time activities as either passive (e.g., viewing, listening and taking notes) or active (e.g., reflecting, discussing, presenting). This row of the planner facilitates quick determination of whether class time is being used for primarily active versus passive student work, making it easy to adjust accordingly.

A row for **Location** denotes where activities will take place. While course activities are typically held in a classroom, they might occur productively at a field site, library, or community agency. Specifying where activities need to take place helps in choreographing smooth and efficient use of class-time.

A row for **Media & Materials** identifies forms of information delivery and associated supplies and equipment, such as slides and projectors, whiteboards or flip charts, and markers, handouts, demo items, etc. Thinking through these details ahead of time helps to ensure that the right tools are at hand for making the most of student time in class. Having this information accessible at a glance also provides a means of rapidly assessing whether class time is overly devoted to a given form of information delivery (e.g., PowerPoint slides).

Finally, the planner provides space for **Reflection** about the course period after executing the plan. We found it was both easy and useful to take five minutes right after class ended to jot down impressions of how the plan worked and suggestions for refinement. Reflections might include impressions of student engagement, match of first exposure to in-class activities, timing, organization, perceived learning outcomes, and ideas for improvement. Keeping reflections short and sweet (bullet points are effective) helps ensure that reflections are faithfully recorded as soon as possible after the course period, while impressions are still fresh. This small-time investment facilitates continual improvement in teaching and learning activities and outcomes, and becomes an invaluable starting point for preparation of class material in future course offerings.

Application of the backward design planner

We developed the planner to transition a non-majors biology course from a more passive, lecture-focused

[2] When using exam performance as evidence of learning, take special care to avoid testing solely for rote memorization of content. There are excellent guides to developing exams that elicit higher-order learning (Walvord and Anderson, 2009; Fink, 2013).

course to a more active-learning, learner-centered course. Here, we compare before-after plans to illustrate the planner's effectiveness in shifting toward student-centered, active learning in a college classroom. We first briefly introduce the course.

Course background

"The City As Ecosystem" (http://www.indiana.edu/~reyno222/) is a three-credit non-majors biology service-learning course designed to introduce key principles of ecosystem ecology while developing students' sense of place and civic ethic and exploring the applications of ecology to sustainable use of energy and resources. Enrollment is typically about 20 students from all years and diverse disciplines, from accounting and finance to the humanities and the social and natural sciences. The course emphasizes the interdependence of humans and environment and promotes interdisciplinary, systems thinking. While these general themes have been constant since the course's inception, learning outcomes have evolved over time to enhance emphasis on higher-order cognitive processes (e.g. analyze, evaluate; Krathwohl 2002) versus the more vague goal of "understanding" characteristic of more content-focused teaching (Table 1). Students learn to compare natural, cultivated, and urban ecosystems with respect to energy and material flow, biodiversity, ecosystem services, and ecological limits; and to integrate these principles with economic and social factors in order to evaluate and design human-environment systems for greater sustainability. Students also learn skills in information literacy and teamwork that are essential for effectively researching and addressing multidisciplinary challenges.

Service learning provides an excellent learning modality for knowledge, skills, and values needed to understand, appreciate, and act on the interdependence of humans and their environment, and for practicing information literacy and teamwork skills. Students therefore work with community partners on biodiversity, global change and sustainability issues throughout the course. The course promotes biology program competencies in scientific process, information literacy, and thinking critically and ethically about biological research and its societal impact, and addresses biology core program content on flow of energy and matter and connectivity of complex biological systems. For more background on this course and its learning goals, see Reynolds 2015.

Before-after comparison of planner effectiveness

We identified three major ways in which the backward course design planner was helpful in shifting toward a more student-centered, active learning classroom. First, the planner prompted identification of specific, measurable learning objectives and alignment of class activities with such objectives. Second, the planner facilitated restructuring of class time. And third, the planner deemphasized the use of PowerPoint slides and simplified their preparation. We

Table 1. City as Ecosystem course competencies have consistently reflected a focus on human-environment interactions and the themes of biodiversity, ecosystems, global change, and sustainability. Within these themes, competencies have shifted toward greater focus on higher order cognition and application of knowledge, consistent with principles of backward course design.

	Later Course Competencies	
Early Course Goals	Knowledge, Skill	Value
1. To understand the scientific method and the principles of ecosystem ecology, with a focus on basic concepts of energy flow, matter cycling, and biodiversity, and applied concepts of global change and sustainability. 2. To understand cities as a kind of ecosystem, and to show how applied ecosystem science can make cities, and by extension the entire biosphere, more sustainable. 3. To develop quantitative, oral and written expression, teamwork, and critical thinking skills, and to foster a sense of civic ethic and environmental stewardship.	**Biodiversity & ecosystem services**: Make comparisons of natural, cultivated and urban ecosystems in terms of ecosystem processes (energy flow, nutrient cycling), biodiversity, ecosystem services (e.g. supporting, provisioning, regulating, cultural), and ecological limits. **Global change**: Evaluate the human ecological footprint at personal, municipal, and global scales using the IPAT model. **Sustainability**: Integrate environmental, economic, and social concerns in critiquing and designing human-environment systems (e.g. food, energy, built environment). **Information literacy and numeracy**: Identify, evaluate, and apply information from appropriate sources, including scientific literature, to inform, analyze, and persuade in both oral and written form. Comfortably work with numbers and units of measurement, evaluate relative numerical quantities. **Teamwork**: Practice teamwork skills such as communication and coordination, empathy, organization, flexibility and cooperation, responsibility, and compromise	Appreciate human **dependence** on ecosystems. Recognize the scale, **risks**, and ethical dimensions of human-caused global change. Develop civic ethic, sense of place, and a sense of the potential for human **alliance** with nature. **Appreciate wise use of information**, including role of science and mathematics in addressing sustainability issues Develop the interpersonal skills and perspective to operate effectively and advance sustainability in a world of **interdependent relationships**

describe each of these outcomes below, reflecting on ways that the planner was helpful in producing the desired changes in instruction.

Aligning class activities with learning objectives, goals and competencies

Because the planner's backward course design structure prompts the instructor to first articulate specific learning objectives, the means of assessing learning, and preparatory work that can be done by students before class (first exposure), the planner facilitates setting learning priorities that then direct how class time can best be spent. In our experience teaching The City As Ecosystem, this lack of prioritization caused course period activities to default to lectures covering content. Before implementing the planner, the step of developing day-to-day learning objectives that clearly aligned with the overall course competencies (Table 1) was skipped. Instead, course periods within a given unit were loosely planned around theme questions. For example, a unit on biodiversity asked such theme questions as, "What is biodiversity?" And a given course period answered this question with an ~70-minute lecture that failed to leverage rich first exposure readings (Table 2). In contrast, after implementing the course planner, course period plans began by specifying knowledge, skill, and value-learning goals, such as "Understand & apply the Millennium Ecosystem Assessment categories of ecosystem services" (Table 2) that aligned with particular course learning competencies, such as "Make comparisons of ecosystem services" and "Appreciate human dependence on ecosystems" (Table 1). Setting learning priorities and means of assessment helped to refine first exposure activities and generate alternatives to lecturing that helped students to practice and demonstrate their learning (Table 2).

Restructuring class time

The planner makes class time visually explicit by partitioning it into discrete blocks (Fig. 1), putting time management front and center. We found that such partitioning helped to guard against devoting inordinate amounts of time to lecture preparation—a huge relief to the already overburdened professor. Given that a 75-minute lecture period yields just a few 15- to 25-minute time blocks, time blocking helped us to prioritize what students really need to learn in class versus what they could learn outside of the classroom via first exposure texts. And time blocking ensured that the chosen class activities were well circumscribed and focused to fit within available time frames. Before implementing the planner, class time in The City as Ecosystem course was dominated by lecture, with less than 10% of time devoted to active student learning (Fig. 2a). In contrast, after implementing the planner, a typical course period involved a diverse mix of active and passive teaching and learning activities, with over 55% of class time devoted to active student learning (Fig. 2b).

For us, discretizing planning into multiple components encouraged earlier, more frequent, and shorter sessions of planning for each week's course periods, in line with expert recommendations to prep in "brief daily sessions" (Boice 1996). The planner thus resulted in more systematic and manageable class time preparation (Boice 1996). We found that putting emphasis on student activities (versus instructor lecturing) likewise reduced instructor "performance anxiety," as well as supported a more creative approach to planning.

Deemphasizing/simplifying powerpoint slides

By shifting the focus of class time to specific, measurable goals and student-centered learning, the backward design course planner helped us to use PowerPoint as a tool to pique interest and direct activities, rather than as a vehicle for delivery of detailed content. Our PowerPoint presentations for the unit on biodiversity created before versus after adopting use of the backwards design course planner exemplify this different use of PowerPoint (Fig. 3). Before the planner, PowerPoint slides were the main vehicle for presenting information in the classroom, and the presentation length averaged 17 slides per course period and tended to be text-heavy (Fig. 3a). These pre-planner slides were laborious to make, taking many hours to choose and assemble text to fit the screen. After working with the course planner, the purpose of the slides shifted away from delivery of content to piquing interest and prompting learning activities (Table 2). The average presentation length was reduced to nine slides per course period, and the majority of slides featured full-screen visuals and little to no text (Fig. 3b). After use of the planner, making slides became a much faster, more creative, and fun process of selecting powerful images or quotes and writing minimal text prompts to guide activities. This change in content and style of PowerPoint slides went a long way to changing course period preparation from a laborious, dull, and anxious process to a fun, creative, and uplifting process.

Unit versus course period planning

The preceding discussion has focused on planning a given course period. Our backward-design course planner can also be applied to planning a unit, or linked series of course periods occurring over multiple days (Fig. 1). In fact, the bigger picture process of unit planning is an obvious first step before getting into the details of a given course period. By laying out the full series of learning goals and competencies for a given course unit,

Table 2. Comparison of before- versus after-planner lectures from a unit on biodiversity.

Course Component	Before Planner	After Planner
Goal of Course Period	Teacher-focused goal of covering content to answer the theme question "What is biodiversity?"	Student-centered goal of developing specific course competencies in the area of biodiversity and ecosystem services: Make comparisons of natural and cultivated ecosystems in terms of biodiversity & ecosystem services Knowledge, skills: • Understand & apply the Millennium Ecosystem Assessment categories of ecosystem services • Make connections between ecosystem services and human well being **Values:** • Appreciate human dependence on ecosystems
First Exposure	Readings: • Eldredge N. 1998. Life in the balance. Natural History 6:42-53. • Daily GC, Ellison K. 2002. The new economy of nature. Prologue: The wealth of nature. pp. 1-17. Island Press/Shearwater Books, Washington, DC. • Tallamy DW. 2007. Chapters 2-6 In: Bringing Nature Home. Timber Press, Portland, OR. Homework Questions on the Readings: 1. According to Niles Eldredge's article "Life in the Balance," 1. What exactly is "biodiversity" 2. Why is preserving it important to humans? Describe at least two examples to illustrate your answer. 3. What are some critical steps we should take to stop the Sixth Extinction? Discuss at least two of his suggestions that you find most important. 2. In their prologue "The Wealth of Nature," Daily and Ellison strongly argue for assigning dollar values to "nature's services." Describe the gist of their argument and explain why or why not you agree with it. 3. Douglas Tallamy's chapters from his book "Bringing Nature Home" discuss the biodiversity crisis as it applies to the suburban lawn's typical emphasis on alien plants. 1. According to Tallamy, why can alien plant species be problematic? 2. Because of the problems associated with alien plants, Tallamy makes an argument for fostering native plant biodiversity in our lawns. Emphasizing native plants in landscaping is often called "green landscaping" or "natural landscaping". Green landscaping can be controversial, as some people favor traditional lawns and feel that wild areas are unattractive and/or unsafe and reduce property values. Indeed, many cities, including Bloomington (see http://bloomington.in.gov/code/_DATA/TITLE06/Chapter_6_06_REFUSE_AND_WEEDS/index.html "6.06.030 Excessive Growth") currently have "weed laws" that require lawns to be kept mowed below a certain height. What are the benefits of green landscaping in terms of biodiversity and ecosystem services, and how can the conflict between those favoring traditional mown lawns versus those favoring green landscaping be resolved? (A helpful website may be: http://www.epa.gov/glnpo/greenacres/weedlaws/).	Readings: • Statement from the Board. 2005. Living beyond our means. Natural assets and human well-being. Millennium Ecosystem Assessment. Retrieved from: http://www.millenniumassessment.org/en/BoardStatement.html • Louv R. 2012. Fountains of life. The Mind/body/nature connection. pp. 46-55 in: The nature principle. Reconnecting with life in a virtual age. Algonquin Books of Chapel Hill, Chapel Hill, NC. Homework Questions on the Readings: 1. After reading the Statement from the Board of the Millennium Ecosystem Assessment (focusing on pp. 3-9), imagine introducing the basic concept of ecosystem services to your neighbor, who has no background in biology or ecology. How could you explain the concept, using a colorful example, in a way that would make sense and resonate? 2. Considering the figure on p. 7 of the Statement from the Board, how would you categorize the ecosystem services discussed by Louv in the chapter "Fountains of Life?" 3. From either of the two readings, pose a good question for class discussion.

(*Continued on next page*)

Table 2. (*Continued*)

Course Component	Before Planner	After Planner
In-class Activities	**Lecture: Biodiversity – origins, scales, estimates & threats** • **Introductory remarks (2 minutes)** about the role of biodiversity in sustainable cities. • **Active learning exercise (5 minutes)**: Project an image of a natural ecosystem, such as a pond or forest. Ask students to reflect on the various possible benefits of the ecosystem and record their ideas on paper (collect these and review after class as means of recording attendance and assessing existing knowledge). • **Lecture with associated PowerPoint slides (68 minutes)**: Origins of universe, earth, life, biodiversity. Definition, scales, and estimates of biodiversity. Threats to biodiversity.	**Hook (13 minutes):** • Provide samples of tea made from *Echinacea purpurea*, a prairie species native to the eastern United States. • Contextualize *E. purpurea* in terms of prairie grassland ecosystem • Ask students to brainstorm ecosystem services of prairie grassland • Share on board • Discuss whether this list reflects all the possible values of prairie grassland **Present learning goals (2 minutes)** **Mini-lecture (10 minutes):** • Consider ecosystem services in terms of course competencies, define ecosystem services **Active learning (30 minutes):** • Practice categorizing ecosystem services in terms of the Millennium Ecosystem Assessment categories & connecting services to human well-being. (15 minutes) • Discussion of Reading 2 – students work in small groups. Reserve a few minutes to survey groups for discussion points, recording these on the board, to facilitate whole class sharing. (15 minutes) **Service-learning orientation (20 minutes):** Short presentation by service-learning community partner involved in restoring, researching and educating about native biodiversity and ecosystem services in urban forests. The presentation introduces students to the partner's work, the services needed from the students, and logistical details (contact information, work times, etc.).

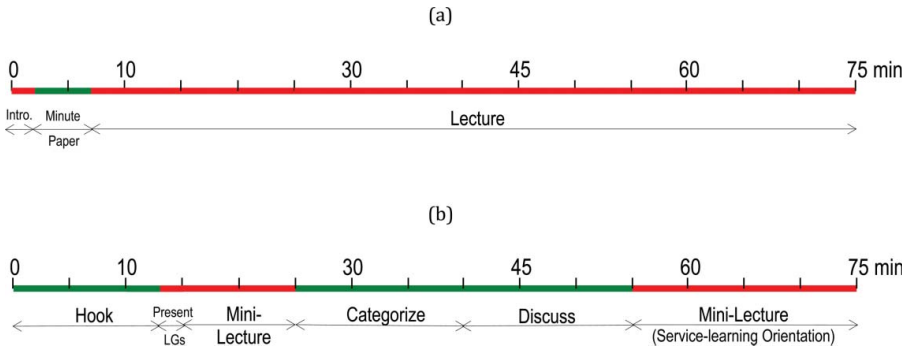

Figure 2. Time spent on different active (green) versus passive (red) teaching and learning activities in sample course periods from a unit on biodiversity (a) before versus (b) after implementing the planner.

unit planning helps identify the most relevant first exposure activities and pace day-to-day activities so as to meet and assess all the learning goals with as much active student work as possible. Unit reflections require consideration of how the whole unit played out and/or patterns that emerged across course periods regarding time management. This level of reflection requires revisiting and summarizing individual course-period reflections.

Student responses

How did the students experience these different classroom approaches? Again, we emphasize that our intention was not to quantify student learning outcomes or student satisfaction with the course. Rather, we wanted to know whether students perceived value in the different use of class time. In the absence of a well-controlled study to answer this question, we turned to student comments written for end-of-semester university course evaluations for insight. We acknowledge several caveats associated with use of these student comments as a gauge of student response to the course planner. First, because we developed the planner over a series of semesters and did not offer the course yearly, several years separate our before- (Fall 2009, Fall 2010) versus after- (Spring 2014, Fall 2014) planner evaluations. Over

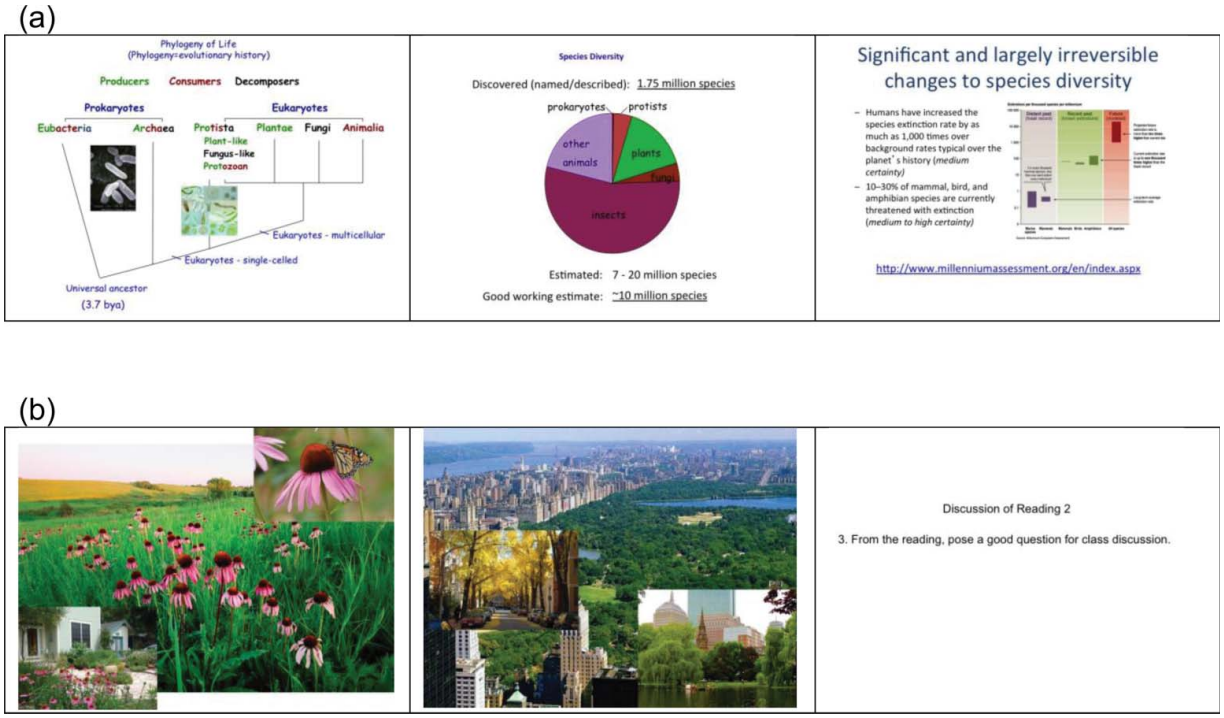

Figure 3. Example PowerPoint slides for sample course periods from a unit on biodiversity (a) before versus (b) after implementing the planner. Pre-planner slides were aimed at delivery of lecture content and tended to be text-heavy as well as numerous. In contrast, post-planner slides tended to focus on piquing interest and directing student activities.

this span of years, certainly many known and unknown variables besides class-time planning for more activities changed. Two important known changes were the number and kinds of service-learning partnerships and the introduction of mini-exams to the course. In addition, the university changed to an electronic course evaluation system starting in Fall 2014. With the change to electronic format, the number and kinds of questions about the course and instructor changed substantially. Finally, the course evaluation sample sizes were small and therefore more prone to be skewed by outliers, both positive or negative.

The shift in locus of activity from the instructor to the student or to student discussion group did result in perceptions by a couple of students of a loss of instructor authority and a diminished sense of course rigor. For example, a couple of student responses indicated that moving class time from content-heavy lecture to student activities was perceived as less rigorous "busy work." Despite these caveats, we noticed qualitative differences in students' feedback that indicated students noticed and appreciated the opportunity to use class time to actively engage with course material. Before implementing the planner, student comments predominantly related to content, their need to know things, instructor knowledgeability, and references to the subject matter (e.g. "There is lots of information presented, she is entirely knowledgeable"). There were also several explicit comments for less lecturing, more discussions, more interactions, more student input, and more examination of local systems (e.g. "Less lecture, more interaction" and "Not enough discussion, too much lecture"). In contrast, after implementing the planner, students noticeably wrote more about impact, appreciation, applicability, and value (e.g. "I enjoy the active learning as well as the project we did…very good at engaging class in discussions" and "Acting on what we discussed in class gave me greater appreciation for the material").

To help ensure that texts and associated questions prepare students on content without being perceived as busy work, we incorporated questions that asked students to analyze, synthesize, and reflect on reading material (rather than questions of simple fact that did not promote deep engagement with the material). To combat the perception that in-class activities are less rigorous than lecture, we planned instructor "debrief" time after student-centered activities to provide essential opportunities to identify key take home points, clear up points of confusion, or offer information or perspectives that had not emerged from student work. Debrief time generally takes 10–20 minutes, and is facilitated by use of a whiteboard to collect ideas, illustrate connections, and add information. In our experience, these strategies are simple to implement, result in richer class discussions, and promote more effective use of instructor authority in the classroom.

Reflection & conclusions

From our observations, class time was markedly more active for students after implementing the backward design course planner (Fig. 2). Instead of spending most of their time passively listening to instructor delivery of PowerPoint lectures, students engaged in activities that required their active involvement, such as group discussion and reporting, measuring and calculating, or applying course knowledge to creative real-world projects (e.g. letters to the editor, landscape plans). The feel of the classroom shifted to that of a learning community, and students appeared to be comfortable working with one another and animated and engaged by active learning. Quick formative assessments, such as group report-outs or written work such as answers to questions or peer reviews, indicated that students were absorbing and applying learning objectives.

In our personal experience, one barrier to an active, student-centered classroom is psychological, emerging from cultural norms that cast the instructor as deliverer of knowledge content. Indeed, our own experience as college students reinforced these norms: we sat for whole lecture periods quietly recording notes as the instructor discoursed, sometimes supplementing their speech with notes on the chalkboard, overhead projector transparencies, or color slides, and occasionally taking questions from the student audience. When the focus of classroom activity shifts to the student, and the instructor's role shifts to facilitator rather than deliverer of knowledge, such norms may challenge both instructor and student perception of the instructor's authority and the course's rigor.

Backward course design's simple, rational framework for student-centered learning vests the instructor with a new source of authority as expert facilitator—the ability to identify the critical proficiencies that students should develop, authentic ways for students to demonstrate their learning, and varied and active means for students to acquire the learning. By providing a concrete tool for enacting this new learning framework from day to day in the classroom, we found that our planner plays an important supporting role in creating a new source of instructor authority. Other benefits of implementing the backward-design planner included the enhanced ability to prioritize content delivery to students; better time management in and out of the classroom; improved experience of lecture preparation, including reduced anxiety and more creative flow of ideas; more engaged students; and more frequent feedback on student comprehension.

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