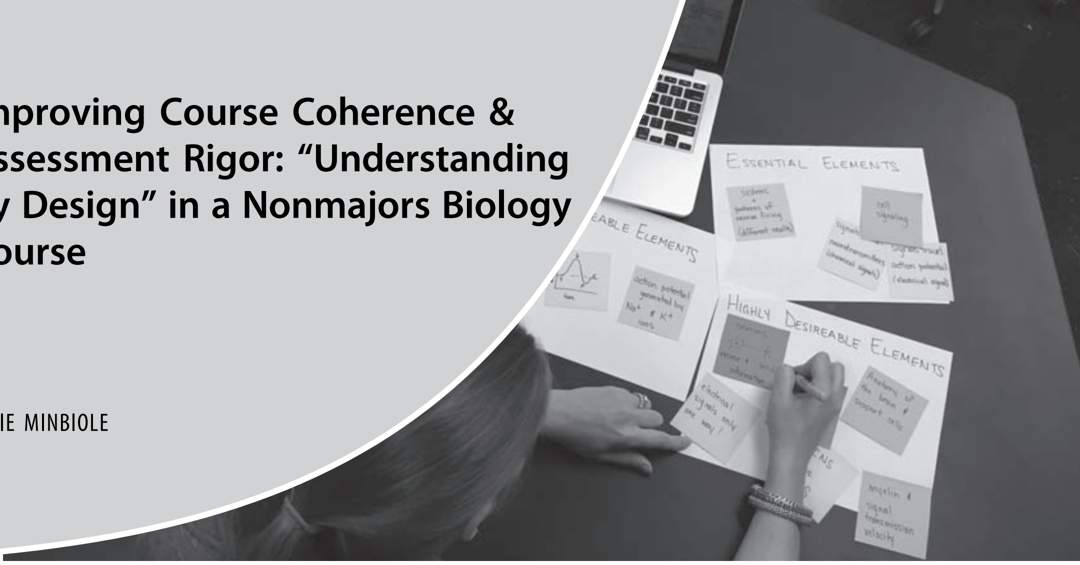
FEATURE ARTICLE

Improving Course Coherence & Assessment Rigor: "Understanding by Design" in a Nonmajors Biology Course



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ABSTRACT

Instructors in two- and four-year undergraduate institutions face a variety of challenges in designing and delivering high-quality courses for their students and in creating accurate assessments of student learning. Traditional course planning (a linear, start-to-finish process based on the knowledge and perspective of the instructor) can lead to lack of clarity of learning objectives for students, uncertainty about course priorities for both instructor and students, and poor alignment between course material and assessments. To address these issues, Understanding by Design (UbD), a course-planning protocol widely used in K–12 education, was implemented to redesign a one-semester, nonmajors "Sensation & Perception" course at a four-year liberal arts college. This implementation improved the instructor's understanding of desired student learning outcomes, allowed core concepts and science competencies to be prioritized as recommended by the "Vision and Change" reform initiative, and led to decreased lecture time in favor of greater lab and student-driven discussion time. In addition, this process allowed components of evidence-based reasoning and scientific process to be incorporated authentically into assessments. Despite the increasing rigor of assessments, there was a statistically significant increase in students earning an A or B on the final exam after UbD implementation.

Key Words: *Undergraduate biology; course design; curriculum design; Vision and Change; Understanding by Design.*

○ Introduction

The "Vision and Change" initiative outlined by the American Academy for the Advancement of Science (AAAS, 2011) was developed to enhance biology teaching at the undergraduate level. Its recommendations stress the importance of student-centered classrooms and learning outcomes and of understanding key concepts and competencies. This initiative parallels a serious flaw I uncovered in my nonmajors undergraduate courses: my students needed clearer focus for our classwork and more coherence between instructional tasks and assessment. I first became aware of this need in the spring of 2014, from a student comment on a course evaluation: "[The instructor] sometimes talks about needless information in her lectures." This took me aback, because I believed that *everything* I had chosen to include in class was important. How else could I design a rigorous, conceptually rich course?

This new perspective raised other questions about my course and my teaching philosophy. Were my instructional goals clear to me, and did my materials and assessments serve these goals? Did the students have a clear picture of course goals? I realized I had to concretely determine what I wanted students to take from my course and better communicate this to them. I also wanted assessments that more clearly revealed students' ideas and misconceptions – both in coursework and in exams. Such a challenge requires careful articulation and prioritization of goals for student learning, a detailed look at assessment design, and precise selection and sequencing of instructional materials and experiences.

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Excitingly, a framework used widely in education of younger students provided the scaffolds and tools I needed for these complex and potentially challenging tasks. The Understanding By Design (UbD) framework developed by Wiggins and McTighe (2005) has led to significant gains in K–12 student learning (Brown, 2004). Here, I describe and analyze my use of UbD in redesigning "Sensation & Perception," a nonmajors biology course aligned to department-wide learning outcomes (standards) to satisfy the science-with-lab requirement for all undergraduates. This course utilizes anatomy, neurobiology, neuroimaging techniques, and psychophysical methods to explore human sensation and perception. The lessons I learned in applying this framework and the difference it has made in the student experience in my class reflect the significance this planning can have for majors and nonmajors alike. The UbD planning tools offer instructors

The American Biology Teacher, Vol. 78, No 6, pages. 463–470, ISSN 0002-7685, electronic ISSN 1938-4211. DOI: 10.1525/abt.2016.78.6.463.

manageable, concrete action steps to undertake and implement course changes recommended by *Vision and Change* (AAAS, 2011).

○ Traditional Course Design vs. "Backward" Design: Opportunities & Challenges

Courses offered at two- and four-year undergraduate institutions can essentially be divided into two groups: introductory or survey courses and special topics (elective) courses. Additionally, many courses are explicitly geared toward either a majors or a nonmajors population. Each of these course types presents challenges for instructors, and the challenges can vary by course type (see Figure 1). Introductory courses such as General Biology, Genetics, or Cell Biology may have more widely accepted bodies of knowledge as represented by textbooks or traditional curricula. However, the breadth of content in these fields requires instructors to select and prioritize topics to fit the course into a semester.

Special topics and elective courses can offer instructors more freedom in selection of topics but may pose greater challenges around science practice and prerequisites. If a particular elective is the only science course a student takes, have they had the experience of "doing science" with enough exposure to science practice (*Vision and Change* competencies)? If electives do not have defined prerequisite courses, does that make them essentially 100-level courses? Answering such questions falls to the individual instructor, who makes choices about the scope and sequence of topics in the course, selection or creation of instructional materials, and design of assessment. UbD offers a planning framework to help instructors address some of these challenges in their course in a stepwise manner. This framework includes elements focused on clarifying goals and objectives, prioritizing course elements to serve those goals, and creating assessments aligned to goals. All of these elements rest on two core principles: "understanding-as-inference" (discussed in the next section) and "backward design" (Wiggins & McTighe, 2005).

Instead of planning a course in linear fashion from beginning to end, or dividing course time between topics according to their breadth or importance, backward design asks the instructor to first envision their target end result (see Figure 2): "Where should students be at the end of this course?" "What should they understand?" The answers to these questions define the "end" of the course, both in purpose and in time. This focus on student understanding as a goal helps instructors avoid the pitfalls of planning around familiar activities or simply covering content.

For example, rather than doing the macromolecule testing lab common to many introductory biology courses, backward design asks instructors to consider what they want students to understand about macromolecules, then decide whether the Benedict's reagent lab advances those understanding goals (Wiggins & McTighe, 2005).

Thinking about understanding goals can be very useful when considering introductory courses for majors, as a way of ensuring that students have understandings that prepare them for future courses in a sequence. A select group of undergraduate instructors in both the Summer Institutes on Undergraduate Education in Biology and the Faculty Institutes for Reforming Science Teaching initiatives in 2009 have been trained in UbD implementation for introductory biology courses (Momsen et al., 2010). This article provides a framework for applying the principles of UbD to the unique challenges of a variety of biology courses (see Figure 1), based on my work with a nonmajors population. For the majority of my students, Sensation & Perception will be the last science class they ever take, so I want to be intentional about the understandings they take with them, and I want their experience of taking a science course in college to be a memorable and

	Introductory Courses	Special Topics / Electives
nonmajors	-(How) is this different from the "majors version"? (***rigor***) -What will students find interesting / relevant?	-How does this course address core concepts & competencies? -Does this course advance scientific literacy for liberal arts students?
majors	-Does this course prepare students for upper-level courses? (***rigor***) -Which content is emphasized? Is this consistent across sections / instructors?	-Does this course depend on prerequisite coursework? -Do students know how to communicate this science to a general population?

Figure 1. Instructor challenges in designing and planning undergraduate courses by topic and student population. Course design challenges vary widely, depending on course type and student population. Instructors teaching majors courses are subject to sequence: introductory courses must prepare students to take upper-level courses, and those upper-level courses depend on students' prior understanding attained in their intro courses. Instructors teaching nonmajors courses have the independence of not serving a sequence but deal with the challenge of not depending on prior coursework to foster student understanding. All courses must also deal with issues of student interest and expectations for science practice and scientific literacy.

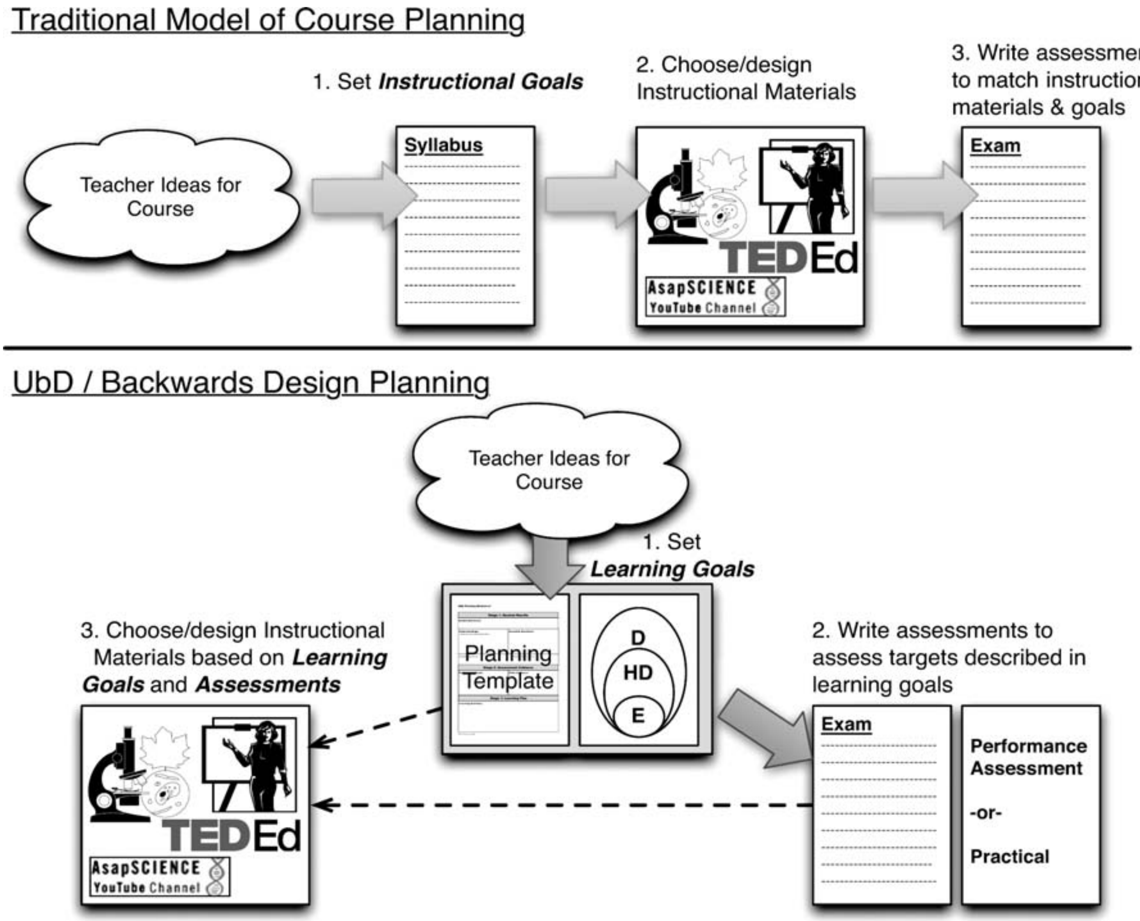

Figure 2. Comparision of traditional course planning and principles of backward design as described by Wiggins and McTighe (2005). Traditional course planning encourages linear, start-to-finish thinking by instructors (Fink, 2007). The syllabus represents an instructional plan for addressing topics, leading to the selection of instructional materials, lab activities, and course assignments. These instructional materials become reference materials as instructors design summative assessments. Backward design begins with instructors identifying desired student understandings and performances that would demonstrate these understandings (learning goals). Summative assessments are designed as acceptable evidence of student understanding (performance goals). These learning and performance goals are then used simultaneously to select and design instructional materials and course activities – in backward design, the coursework is designed after the summative assessments.

empowering one. Science has a reputation for being confusing and disjointed. If there are attitudes that I can affect with the quality of my course design, it serves to keep more citizens in the fold of scientific curiosity. Making concepts more cohesive makes them less threatening, which, I hope, means that more of my students will feel comfortable engaging with scientific concepts after they leave my course.

These goals of making content clearer to students and more accurately assessing deep understanding are hardly revolutionary. The goals themselves were not new to me; the story of UbD for me is about having sufficient tools to tackle the problems of course design for someone without the sort of formal training in pedagogy common in the K–12 world. The external structures we are provided as undergraduate instructors, like sequencing of content in the textbook or syllabi from other instructors, are not necessarily aligned to our instructional goals or the needs of our particular student base. Structures and sequence that work for one instructor and student population may not work for another. There isn't necessarily a best sequence or set of goals for any given course, but one of the great challenges facing undergraduate instructors is a lack of good tools to organize the goals and sequence we're reaching for in our classes. The concept of backward design and the planning tools that Wiggins and McTighe (2005) have developed can break up the daunting, seemingly overwhelming task of planning or overhauling courses and their assessments into concrete steps.

○ (Re)Designing a Course Using UbD

Understanding by Design provides a stepwise framework for instructors to identify, assess, and support student learning toward understanding. In the following sections, the major steps in UbD planning (as developed by Wiggins & McTighe, 2005) are discussed in the context of redesigning the Sensation & Perception course.

(1) Clarifying Goals & Outcomes

The UbD framework first asks instructors to consider what students should understand at the conclusion of a course. Understanding-as-inference, as defined by Wiggins and McTighe (2005), describes the process by which a learner "understands" as one of making inferences or drawing conclusions on the basis of evidence and reasoning. If students aren't given the opportunity to make these inferences – for example, medical students who were evaluated for retention of anatomical terms with which they had not made concrete connections – the input of knowledge is no more memorable than nonsense syllables (Shulman, 1999). UbD, therefore, requires instructors to articulate desired understandings and component information and skills that students will need to develop these understandings. This information to know, concepts to understand, and skills to perform together comprise the Student Learning Outcomes (SLOs) for the course (Northeast Comprehensive Center, 2011). Separating student learning goals in this way helps the instructor frame the level of detail and support that students will need to meet these goals and provides the criteria for devising course sequencing, student activities, and curricular materials (Wiggins & McTighe, 2005).

The idea of students constructing their own understandings is not new in undergraduate education and is a goal that many instructors have for their courses (Farrell et al., 1999; Gamache, 2002; Fink, 2007). What UbD offers is a defined planning protocol to help instructors structure their courses to support students in developing their understanding. In Sensation & Perception, using the planning template shown in Figure 3 for each course topic helped bring focus to each class period and helped me critically compare the structure and priorities in the text to my ideals. The rigid, worksheet-like structure of the planning templates was an asset – it removed the ambiguity I had in planning coursework for students and forced me to be explicit about my core goals for student understanding. Additionally, the understandings I initially chose as goals felt important but were often difficult to measure. Being forced to articulate performance goals – things I might observe students doing to demonstrate understanding – was a useful way to pin down an otherwise abstract set of goals. These performance goals then formed the basis

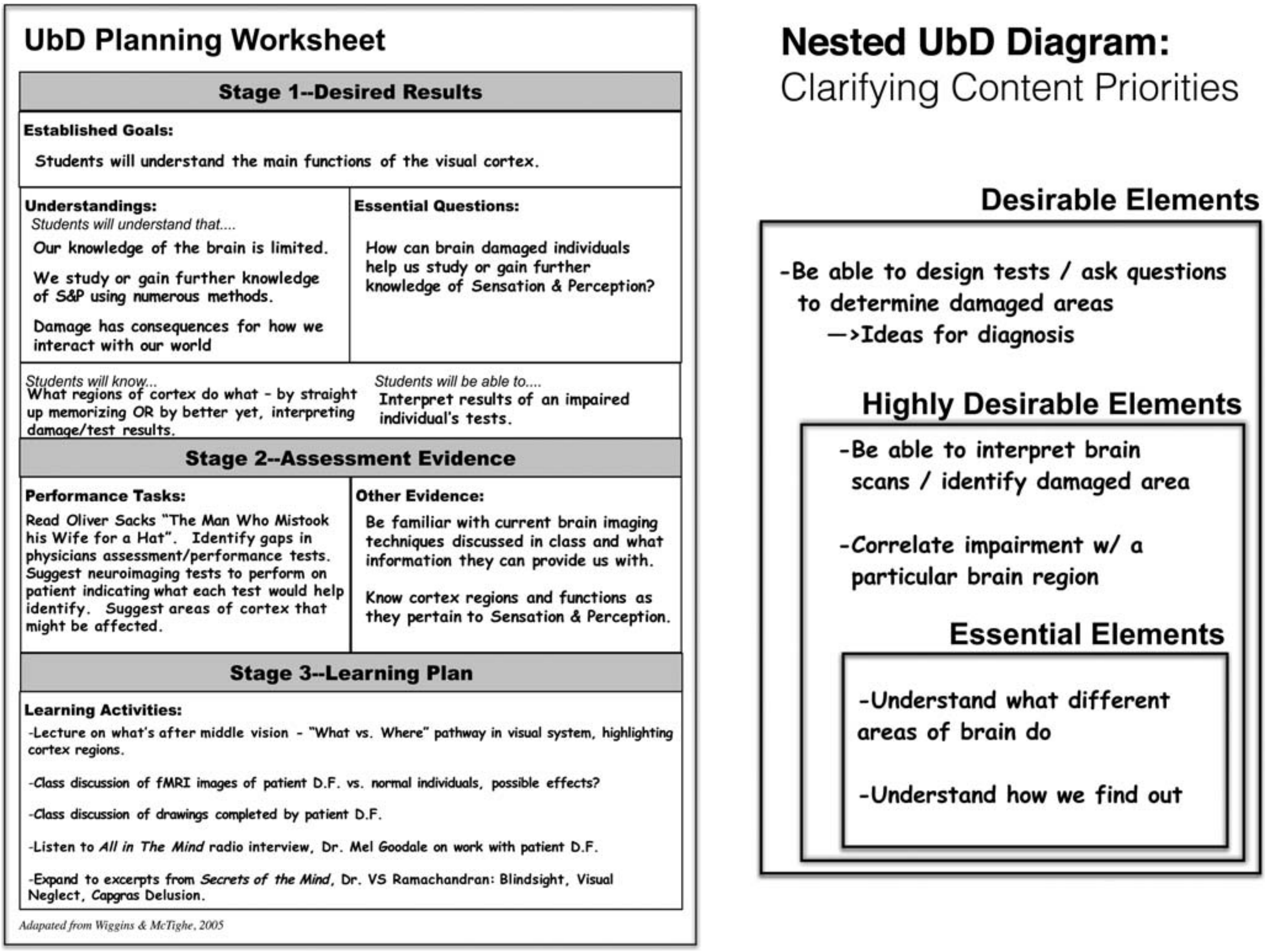

Figure 3. Topic planning templates based on Understanding by Design (UbD) protocol. The backward design protocol described in Figure 2 can be facilitated by use of planning templates and worksheets. The first of these were published by Wiggins and McTighe (2005), but many variations have been made by K–12 teachers. In the "Sensation & Perception" course, each topic (approximately 1–2 weeks of course material) was designed using a one-page planning worksheet and a nestedness/prioritization diagram. The planning worksheet provides structure for identifying learning goals (Stage 1: Desired Results), performance goals (Stage 2: Assessment Evidence), and selection/design of course activities (Stage 3: Learning Plan). The Nestedness template helped the instructor identify essential understandings underpinning the course and differentiate them from dependent understandings or extension ideas that some students might grasp but that were not necessary for progress to completion of the course.

	Instructional Goal	Traditional Assessment Item(s)
original	"Signal Transduction" "Vestibular System"	**[Test Question]** / What is transduction? *(Spring 2013)* **[Test Question]** / _____ typically result(s) from disagreement between the motion and orientation signals provided by the semicircular canals, otolith organs, and vision. a. Exhaustion b. The tilt aftereffect c. The vestibulo-ocular reflex d. Motion sickness e. Hallucinations
	Student Learning Goal	**UbD-revised Assessment Item(s)**
redesigned	"Students will ***demonstrate understanding of signal transduction*** by **explaining biological processes**." "Students will ***demonstrate understanding of vestibular function*** by **evaluating experimental evidence**."	**[Test Question]** / What is **transduction**? **WHERE** and **HOW** is transduction accomplished in EACH of the systems that we covered in the second half of the course? (Touch, hearing, smell, taste, and the vestibular system.) *(Spring 2015)* **[Test Question]** / The vestibular system heavily relies on input from what sense(s)? What evidence do you have to support this?

Figure 4. Comparison of traditional goals and assessments with Understanding by Design (UbD) student learning goals and assessment. Examples of content-focused instructional goals in the pre-UbD "Sensation & Perception" course, and their corresponding assessment items compared to student learning goals and corresponding assessment items in the UbD redesigned course. The UbD planning to produce goals that led to more specific performance-based assessments also allowed incorporation of core competencies (science skills and practices) recommended by the *Vision and Change* guidelines (AAAS, 2011).

of assessments for the course, both formative and summative (see Figure 4). A few weeks before the semester began, I filled out 11 planning documents by topic, spanning the entirety of the semester-long course; each planning document usually took 60–90 minutes to complete. I then revised many of these documents in the week leading up to their respective topics, taking an additional 30–60 minutes to look at learning goals before revising my course material for that week.

(2) Prioritizing Elements as Essential, Highly Desirable, or Desirable

Wiggins and McTighe (2005) recommend prioritizing concepts for each topic into a three-level hierarchy illustrated in the Nestedness diagram in Figure 3. "Essential" elements are elements that all students should have a strong understanding of, either because of the importance of the idea in the course or because other ideas depend on that Essential element. "Highly Desirable" elements are still important, but usually not as foundational – they have fewer dependent ideas. These are ideas that all students should have, but course completion does not depend on them. Lastly, "Desirable" elements are not necessary for course completion, nor do they have any Essential or Highly Desirable dependencies. These are ideas that "it would be nice" for all students to have but are not necessary to build as a class (Wiggins & McTighe, 2005).

UbD challenged me to take a step back from my belief that everything in the course was important and prioritize how important each aspect of the course was to achieving the SLOs I had created. The biggest shift was in identifying Desirable elements: aspects of the topic that required mastery of the Essential and Highly Desirable elements and did not provide critical connections to other content, but that provided those students who were high achievers additional extension to stimulate their curiosity and understanding. Items that fell into this category, I realized, were not required for successful completion of the course. When assessing student learning of these Desirable elements, I constructed open-ended quiz or exam questions that allowed students to demonstrate their high-level understanding but did not penalize students who didn't demonstrate understanding of Desirable aspects of the content.

Before UbD planning, I was proud of my course; I felt I had chosen 15 weeks of material that best encapsulated the science of sensation and perception. Creating and prioritizing these elements, however, forced me to examine the mechanics of interconnected information and student understandings. For example, in a genetics course, the basics of transcription and translation are Essential elements. They are important on their own, but a great number of other understandings in the course are dependent on these concepts. The belief that I, as the instructor, had to address all the topics became replaced with the idea that my job was to identify the core ideas – the Essential elements – that students should grasp and then create opportunities for students to build these understandings for themselves. As a result, I reduced the amount of content and time I spent lecturing by approximately half, thus allotting more class time for discussion, video clips, and lab activities (see Figure 2). Student-led discussions were often focused on current and newsworthy developments in the fields of neuroscience and sensation and perception.

Removing the "interesting but inessential" Desirable elements from lecture and mandatory presentation had an unexpected outcome: students now had the opportunity to introduce these elements into class during our discussion time, and I gained new formative assessment opportunities as a result. To make this happen, I had to cut material that I had previously worked hard to create, restructure labs and lab questions, and even create new lab activities. This represented a sizable investment of time and energy, and it also required the discipline of always referring back to my goals. I couldn't hang on to things I had made before when I could see, from my planning sheets, that they didn't serve to advance the Essential understandings I wanted my students to have. In this way, the backward design process and the planning sheets themselves kept me honest and accountable in editing the content to achieve the goals I set.

(3) Assessment Design Based on Desired Learning Outcomes

Rather than the model of an instructor teaching the course, then returning to their notes and course materials to write assessments, UbD gives instructors a structure for designing both assessments and course material as a direct response to learning goals in the planning document. This set of goals can be shared with students as part of the syllabus or weekly agendas, further demystifying course expectations and giving students direction in their preparation. For many of my nonmajors, quizzes and exams can be mysterious and scary things that they feel unprepared to tackle. Sharing a clearer set of objectives allows students to focus on thinking deeply about the biology, rather than worrying about surprises on exams (Wiggins & McTighe, 2005).

In Sensation & Perception, UbD clarified my assessments' prompts to address student understanding or misconception more directly (see Figure 4). I also found that my thought process in designing assessments before UbD had been dismayingly topic-based. Previously, when reviewing lecture materials and coursework to write assessments, I thought, "I need five to ten questions addressing the vestibular system." Now I planned my assessments, and subsequently my instruction, on the basis of deeper questions: "What do I want them to know about [this topic], and what evidence would convince me that they know? What can I ask them to do to show me they understand? What scientific skills would they have to practice to display the evidence I'm looking for?"

These questions have informed the instructional choices I make and the tasks I assign to students. In the vestibular-system lab, for example, students stand on balance boards and attempt to maintain balance with eyes open and closed. Rather than "asking questions about the vestibular system" on a subsequent assessment (see Figure 4), I'm asking them to think about work that we did in class and to demonstrate their understanding of lab activities by connecting them to mental models of how the senses operate. In this way, labs become more than enrichment or confirmation exercises – they become necessary parts of building scientific knowledge in the course.

In this way, identification of desired student understandings for each topic in the course led to the redesign of the midterm and final exams. Before UbD planning, the final exam was ~70% multiple-choice questions and ~30% short-answer (see Figure 4). After UbD redesign, this distribution of question types was flipped to 70% short-answer and essay questions, all focused on learning objectives that I established at the start.

○ Outcomes for Students

From an instructor's perspective, the changes made to the course as part of the UbD redesign appeared most immediately in two ways: more students seemed to "ace" the exams, despite increased use of short-answer and essay questions and demands for evidence to support their answers (see Figure 5), and students seemed more engaged in class, as evidenced by students bringing relevant current events, articles, and extension questions to class. Students commented in course evaluations about instructor behaviors they felt had fostered their engagement (see Table 1), but those student-

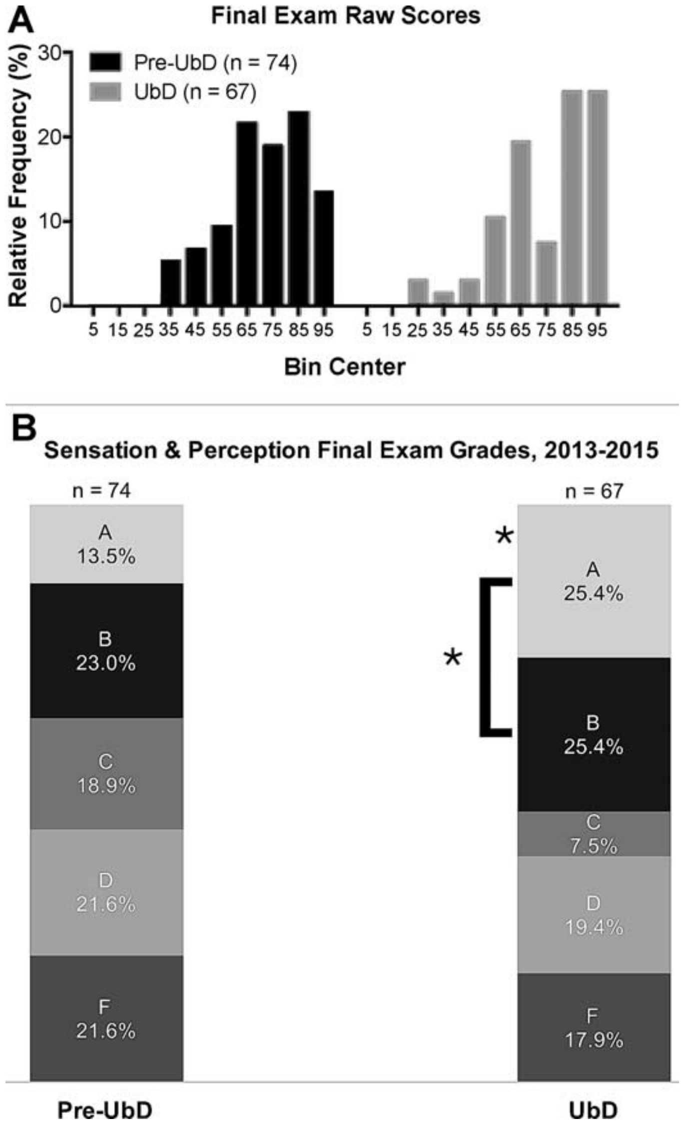

Figure 5. Student performance in a special topics course before and after redesign. Student final exam scores before and after the Understanding by Design (UbD) redesign (panel A) resulted in the exam grade distribution shown in panel B. There was no significant difference in the number of students passing (earning C or higher) before and after the course redesign using UbD, but the number of successful students (exam grades of A or B) and highly successful students (exam grade of A) were significant at P = 0.05 using a two-sample test of proportionality.

Table 1. Student and faculty-peer comments on course activities after Understanding by Design (UbD) redesign. Comments A–C are taken from student end-of-course evaluations, and comment D comes from a faculty-peer evaluation from spring 2015.

A	"[Instructor] relates back to the arts[a] and that is very helpful for everyone in class. We have amazing conversations and every topic we talk about is interesting. We have quizzes every week, which at the beginning I thought would be horrible. But once the midterm and final come around you are almost thanking her because refreshing our memories of the prior weeks topics is super helpful. All the labs we do are engaging and useful for the future."
B	"[Instructor] was always very precise and clearly communicated a structured schedule and daily agenda for the topics we covered in class. She taught with a variety of tools. . . . She always related the information to the fields of study offered at [our college] (dance, advertising, fine art, etc.)."
C	"All of the labs were exciting and valuable for me."
D	"[A] regular feature, in which the students and [instructor] talk about media reports related to the subject of the course; this time, two students had seen something that they shared with the class, and [instructor] added one more media report to the mix. . . . Students were both comfortable with and stimulated intellectually by the subject matter, and the level of activity of the class was high."

[a]This course is taught at a four-year liberal arts college with a focus on arts and media.

provided materials and student-centered discussion have been shown to increase student excitement, engagement, and comfort in science (Sundberg et al., 1994). Additional time for these discussions was made possible through reduction of lecture material as a result of UbD planning. Essentially, students were giving me credit for the additional engaging work that they produced, when I simply cleared time for their curiosity.

To evaluate the first observation regarding student performance, a two-sample test of proportionality was conducted comparing three sections of students given pre-UbD final exams (n = 74 students) to three sections of students given UbD-informed final exams (n = 67 students). In this comparison, the proportion of students who were successful on the exam (defined as earning ≥80%) in the UbD group was significantly higher (α = 0.05) than that in the pre-UbD group, using a test of proportionality of two populations, as shown in Figure 6. Additionally, the proportion of students who were highly successful (scoring ≥90%) was also significantly higher in the UbD group (see Figure 5). Using UbD, there was less direct instruction, and exams now required students to provide justification for their answers (Figure 4), but there was still a higher proportion of students earning A's and B's.

$$z = \frac{(\rho_1 - \rho_2) - 0}{\sqrt{(1-\rho)(\frac{1}{n_1} + \frac{1}{n_2})}}$$

Figure 6. Z-score calculation for comparison of proportions in two populations.

The second observation, that students seemed more engaged, is more difficult to quantify but was visible in student-driven discussions that became a large part of class. This engagement is also reflected in students' comments on course evaluations and comments of a peer evaluator (see Table 1). UbD planning allowed me to increase the time allotted for student discussion and allowed this discussion to be student-driven yet still focused on core understandings. This increased student focus had a noticeable impact on the culture in class. As I talked less, students took on more work of discussion and analysis. For example, a student interrupted my description of the push–pull symmetry of the vestibular system for horizontal head movement, to accurately explain the concept to the class while rolling out and spinning in his rotating lab chair. Interestingly, students have commented since the UbD redesign that I "relate course material back" to their majors and interests (Figure 5B), but this is not entirely accurate. I have not made these connections explicitly, but rather provided more time for discussion. Students are making these connections and attribute them to the instructor or structure of the course.

○ Equity & Access

The UbD framework offers instructors straightforward tools to improve course coherence, clarify objectives for student learning outcomes, and refine assessments. These course improvements offer a better student learning experience regardless of background (Brown, 2004), but a large body of evidence suggests that some students benefit more than others. Students from traditionally underserved populations, students of color, first-generation college students, and women each show achievement gaps in higher-level science courses (Weis, 1992; Packard & Babineau, 2009; Wilson & Kittleson, 2013). Students from each of these populations have shown greater improvements in performance when courses and assessments are improved using best practices such as UbD (Burk, 2000; Kamler & Comber, 2005). The non-majors population at my institution has generally reported low confidence with science content and practice. The success of UbD with this population is a hopeful sign that this type of pedagogy increases access to rigorous science content for a broader segment of the undergraduate population.

○ Instructor Reflection

The experience I had in beginning this process has been referred to as the "expert blind spot," the idea that instructors are unaware of the differences between student perception of course material and their own (Nathan & Petrosino, 2003). More specifically, because instructors have greater background knowledge in their field than their students, students often miss connections between concepts that seem obvious to instructors. This phenomenon extends so far that students and instructors often report different numbers of topics covered in a course. What instructors see as interrelated and supporting concepts, students see as disconnected and discrete topics (Shulman, 1999).

My perception as the instructor is that students now have a better idea of what's expected of them, as borne out by higher summative assessment scores. Additionally, because my exams now contain more short-answer and essay questions and less multiple-choice, they reveal more about student understandings and misconceptions. In this way exams are not only more rigorous, but also more useful for course evaluation and instructional planning (National Research Council, 2012). Janet Batzli and Tammy Long conceptualize this relationship in their "assessment gradient," whereby short-answer and essay questions have more potential to assess student learning than multiple-choice questions, but make the assessment more difficult for students to complete – and for instructors to design (AAAS, 2011, fig. 3.2). UbD planning provides the framework for instructors to write more rigorous and informative assessments, as well as providing students clarity to prepare for these assessments.

Students have shown me, both in their comments and in their performance on assessments, that many are gaining deep understanding of the course material. This is gratifying, particularly as I have become less active in driving the course. I wanted to spend less time lecturing, because I find it tedious for instructor and student alike but was unsure of how best to use that time. UbD provided a structure that allowed me to cut lecture time in half and still have confidence that students would reach my desired goals with the other class activities. Essentially, UbD provided a framework in which to organize course materials and activities according to my identified priorities for student learning. With this structure in place, I was able to depend more heavily on lab and discussion to ensure that students attained the desired learning outcomes. This shift in my thinking – from planning instruction to thinking about student outcomes – has been the most significant effect and benefit from using the UbD framework.

This takes time – time before the semester starts, and time each week. After three semesters of teaching this, I'm still not done – once was not enough. I was naive about the amount of work that UbD would take. While each topic worksheet took 60–90 minutes to complete, this was a small fraction of the work UbD planning required. I mistakenly took the simplicity of the worksheet to mean that the work that followed would also be straightforward, until I realized that the worksheet was a plan to overhaul my class. Identifying desired student understandings changed my thinking about the purpose of each class. This mindset shift caused me to modify my lectures, rework lab handouts and questions for students, and rewrite my exams to look for desired understanding. I am pleased and proud of all of these changes but have realized that implementation of UbD and backward design is best looked at as a continual and iterative process. The amount of work is well worth it, though. It has reinvigorated my teaching while improving student satisfaction and course success.

○ Acknowledgments

I thank Kirstin Milks and Stephen Traphagen for their work in reviewing this manuscript. I certify that I am not affiliated or involved with any organization or entity with any financial interest in Understanding by Design.

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