From *Overcoming Student Learning Bottlenecks: Decode the Critical Thinking of Your Discipline*

By Joan Middendorf and Leah Shopkow

The following is an excerpt from the unedited manuscript.

Introduction

Why Decoding?

Why do you need another book on teaching and learning?

You may be asking yourself this question, whether you are an individual college instructor or an educational developer. So many books have been published purporting to show the one true path to improved student learning or satisfying teaching. What does this book add to that store?

Teachers want their students to do better work but don't know how to get them to do better work without giving them the answers. Teachers are aware that they want to teach students more than a bunch of content, but they aren't really sure what the more is, although they know it when they see it in their own work and in the work of others. In other words, this is a how-to book about the gap between the way experts and novices think in any discipline (or across fields).

Where this book differs from other approaches to teaching and learning is that it puts a powerful methodology that respects disciplinary difference in the hands of individual instructors.

It does not dictate to instructors what paths they should follow toward improving student learning, but shows them how to find the path that works for them and their disciplines. It provides them with tools for evaluating other teaching innovations to find the ones that fit into their own teaching frameworks. For educational developers, it provides a tool for guiding faculty without experiencing pushback against "alien" (that is, educational) knowledge. And finally, for those who wish it, this methodology provides guidance for creating a teaching commons and for systematic change at the departmental and institutional level.

These are big claims! However, they are based on our experiences working with faculty from a variety of institutions for more than a decade. In the book that follows, we will demonstrate the methodology, provide evidence of its efficacy, and explain the pedagogical theory behind it. In this introduction, however, we want to provide an overview of the decoding paradigm and suggest some of the reasons for its power.

What makes the decoding approach different from many other approaches to educational improvement is that it takes disciplines seriously. By taking disciplines seriously, we do not mean that we think of them as having an objective or eternal existence, that we see them as unchanging, or that we do not recognize that practitioners frequently know or borrow from methods in related disciplines. Nor are we accepting that disciplines are "academic tribes" occupying "territories." (Becher & Trowler, 2001) We are aware of the arguments theorists have had over disciplines and interdisciplinarity, and yet we start from what is: even many scholars who work across disciplines have a "home" or primary discipline which shapes their initial approaches, even if they read widely across disciplines. Most academics teach in departments defined by disciplines and most students take courses in departments defined by disciplines. We would define disciplines, then, as epistemic communities, communities of knowing, that produce

knowledge through certain tacitly agreed-upon rules governing mental moves. We expect our students to be able to make the moves of the disciplines in our classrooms and to understand the rules. Educators have come up with generic models of critical thinking (Paul & Binker, 1990), but our work indicates that critical thinking is specific to each field, differing from discipline to discipline. Educational specialists cannot teach disciplinary experts how to teach—it takes the involvement from within the discipline to define teaching in that field.

Faculty as practitioners may understand their disciplines in this way, as approaches, techniques, applications. However, they tend to organize their courses around specific contents rather than around the mental moves they want students to make. As a result, their efforts to change what students learn may focus on looking for more engaging or effective content or choosing new classroom "activities" in the hopes of promoting student learning. In contrast, decoding focuses on the mental moves students must learn to make to produce high-quality work, spelling out what "critical thinking" means in a specific disciplinary context. These moves are usually unarticulated within a discipline and may even be so completely internalized by practitioners that they are not aware of them. Not surprisingly, instructors do not teach these moves explicitly and students, who have experienced many years of schooling in which they were not instructed in disciplinary modes of thought, may not even realize that particular kinds of thinking are called for in a discipline. For instance, students in physics may be used to plugging numbers into a formula to find the answer, rather than thinking about the problem the way a physicist would. Geology students may think that an earthquake can be summed up in a single number, because they do not understand all the components that seismographers consider when studying earthquakes. History students may think that their job is to memorize facts, because they do not understand how historians construct narratives about the past.

Decoding the Disciplines is a methodology that starts at this gap between novice and expert thinking. It shows how to identify places where students get stuck mentally, called bottlenecks, and how to analyze the critical thinking or define specific mental actions that can get them through the bottlenecks. Through "decoding," *implicit* or *tacit* expert modes of thought can be turned into *explicit* mental tasks. These tasks can then be modeled for students and they can be given the opportunity to practice them. Assessments of the mental actions can then check student performance and reveal where further modeling or practice is needed. The bottleneck and assessment perspective can help teachers in any field become learning-centered and vested in the learner's journey.

When, instead of getting annoyed when students don't "get it," teachers look for the bottleneck students are getting stuck in, their view of what is happening in the classroom shifts. The bottlenecks become helpful indicators. Students are holding up red flags showing where they don't know how to do the critical thinking specific to our disciplines, thus showing us what needs to be prioritized in the classroom and where to dig in. Learning to recognize bottlenecks is a way of recognizing patterns in student difficulties.

In the process of recognizing bottleneck patterns, decoding reveals the tacit knowledge of expert practitioners. This is the revolutionary kernel of Decoding the Disciplines. Although instructors are very good at judging when a student performance does not meet their expectations, they are often not particularly good at identifying why a performance is substandard, what the student *should* or *might have done* to produce better work. An instructor might conclude, for instance, that a student didn't understand the reading—which might certainly be true—but not realize, for instance, that the student read for facts without looking for an argument or didn't understand the purpose of a data section in an article. The instructor might

tell the students, “Read more carefully!” advice that under the circumstances wouldn’t really address the problem. If instructors are not aware of what reading consists of in their disciplines, they can’t make that explicit to students.

Another reason experts may be unconscious of what they do, is because they chunk and process information in larger and more complex units than novices (Chase & Simon, 1973; Glaser & Chi, 1988). They may very rapidly consider a number of possible words before choosing the right word for a poem or a number of features when identifying an artist's style or a number of possibilities for how DNA is expressed. In the example of reading above, for instance, an historian might consider the argument of an article at the same time as taking in quite a lot of factual information, while a geologist might skip to the data section of an article first and then look to the end for the conclusions, all without being conscious of doing so. Thus it takes some practice to learn to decode, but those who do find that mental actions underlie much of what we do in teaching because they reveal where disciplinary critical thinking occurs—the mental muscles we want students to develop.

At this point, you may be wondering about our emphasis on the disciplinary nature of thinking. Don’t we want students to be able to do many kinds of critical thinking? Of course we do! We would make two points about this, however. First, students often believe that there is only one way to think, just as they often believe that there is only one way to read. But how a scientist reads a scientific paper is probably different from how a scholar of English reads a literary article and even within disciplines there are different ways to read depending on one’s purpose. To clarify the differences for our students makes their overall learning—whatever disciplines they study—better.

In addition, making the kinds of thinking done in different disciplines explicit actually puts

an important intellectual tool in the hands of students. When they know different sorts of mental moves, they get to decide which moves they will apply in a given situation. For instance, they may understand how economists think about concepts such as replacement cost, but decide in a given situation that they do not want to think as economists. They may decide to think like historians in their day-to-day lives, but not in their faith communities. They may want to worry about germs and contamination in their labs and not so much in their homes. The same is the case in writing. Helping students become aware of different forms of discourse helps them develop a metacognitive skill—the strategic considerations about writing that differ from discipline to discipline. By deciding on the audience, purpose and discourse for a writing task, students can use the appropriate moves for the task at hand (Bean, 2011).

The bottlenecks students experience in the classroom frequently arise because students see all sorts of concepts and all sources of information as being more or less the same. Moreover, emotions and learning are completely intertwined (Dragon, Arroyo, Woolf, Burleson, el Kaliouby, & Eydhagi, 2008). To learn, one has to physically change, break old habits, and foster new connections in the brain (Timmermans, 2010). Students tend to use the same mental patterns they have always used; it's more comfortable than trying something new. Decoding the Disciplines shows teachers how to help students differentiate between conceptions arising from outside of disciplinary thought from those originating within it, by making the contrast between external conceptions and the disciplinary ways of operating clear.

For example, media encourage students to associate immigration with "illegals" violating American borders in a great uncontrolled flood. In a history class, however, students might instead examine historical patterns showing emigration as well as immigration. They have to understand that that media image is not an historical one. They might, however, consider

historically how this media image came to be. Similarly, in an ethnic studies class, students might look at immigration through the lens of administration. They might look at the government agencies controlling immigration and how these have shifted toward a more militarized and criminalized treatment of illegal immigrants. In addition, they have to understand that the media image of complete lack of control is not supported by disciplinary thought, although they might apply disciplinary thought to consider why this might be so.

Other examples of concepts students may bring in from outside of a given discipline similarly impede their learning. For example, students in a service learning class may understand their efforts in terms of volunteerism, instead of reciprocity (all participants, including community partners, as co-generators of knowledge). And in a geology class, students may think of the age of the earth in terms of their religious beliefs (6,000 years) rather than in terms of science (4.6 b from fossil record and isotopic analysis). In a history class, they may judge historical "winners" and "losers" rather than see events from the viewpoint of a person living in that earlier time. To overcome student resistance to new ways of thinking, we show their conceptual category compared to the expert or disciplinary way of thinking (Middendorf, et al., 2015). We can further help students recognize the difference between the way people think about these issues outside of the discipline and inside of the discipline, contrasting analogies for the two, taking the similarities and differences into account (Jones, Ross, Lynam, Perez, & Leitch, 2011). In other words, decoding can show students the exact mental action (or "mental muscles") to use to operate in a field, while allowing students to recognize that different situations may call for different sorts of thinking.

The Decoding Process in Brief

In the chapters that follow we will write at length about each of the seven steps (See Figure 0.1: The Decoding Cycle) of the Decoding the Disciplines model, but we will present them briefly here:

- Step 1—Identify bottlenecks to learning

  Using student work, we identify a place or places where many students get "stuck" in their learning

- Step 2—Decode what experts do

  We define the mental action a specialist would take to avoid getting stuck in the way the students have gotten stuck

- Step 3—Model the mental actions

  We explicitly model the mental action we want students to do to negotiate the bottleneck

- Step 4—Provide practice and feedback

  We design a classroom practice or assignment in which students are required to perform the mental action. We give them feedback where they need to make improvements.

- Step 5—Motivate students to use the mental action

  We hold students accountable for practicing the mental actions they need to master. We design courses to disrupt old learning habits that impede learning. We provide additional modeling and practice as needed.

- Step 6—Assess student performance on the mental action

We ask students to apply the thinking they have learned to an authentic disciplinary task to see how well they are able to do this.

- Step 7—Share findings with others

  We share what we've found with others, through informal conversations, through discussion in learning communities, through more formal presentations, through the scholarship of teaching and learning, and through strategic decoding and planned change.

Figure I.1. The Decoding the Disciplines Cycle

The first two steps of decoding—the bottlenecks and the tacit thinking of the expert—drive the later teaching and assessment steps, because they clarify what students need to learn. They uncover the epistemology of the discipline and are the intellectual core of the methodology. The next four steps are the application part of the methodology, in which the instructor teaches the students the requisite thinking and measures how effective the instruction has been. These steps are inherently less distinct from each other, as one form of modeling might be to walk students through a practice assignment and practice assignments can be used as assessments. The iterative nature of the decoding process tends to blur the distinctions between these steps. We will speak at length about the seventh step, which individual instructors working alone may not choose to take, but which we have found to be enormously powerful.

It may seem from the above model that decoding is very focused on one specific mental action in one specific discipline and that it is consequently narrow. There are a number of reasons why this isn't the case. Just because our theory is called Decoding the Disciplines, some assume it means we are limited to only working within disciplinary boundaries. Disciplines are silos holding a set of mental actions that make up one way of creating knowledge. By uncovering disciplinary tacit knowledge we can make it available to students. But decoding also works well in cross-disciplinary fields, whose silos are comprised of a different cross-section of mental actions. Our work with cross-disciplinary groupings revealed early on the value of many perspectives, which participants found very helpful and which identified unexpected insights into the similarities and differences among disciplines. For example, close reading can appear in literature, history, and informatics, just as evidence has to be deployed in geology, accounting, and history. When an accountant and a geologist compare their notions of evidence with each other, the similarities and differences help each of them see the epistemologies of their

disciplines more clearly, in other words, it is easier to see the shapes of disciplines in comparison to each other. The cross-disciplinary process creates a transformative community as one participant reported, "This cross pollination of ideas is incredibly deep and is fully shaping my work and professional and personal identities… I am getting increasingly aware of my own thinking and approaches" (Pettit et al., 2017).

The other misconception is that faculty members, when they use the decoding process, are concentrating on just one skill, when students need many skills and that this may be too narrow. When we look at one significant bottleneck, such as in history, where we made our original breakthrough, we realized that the places students got stuck were often connected to the underlying epistemology of history. When an instructor focused on one of these significant bottlenecks, student understanding increased in many areas, not just in the one the instructor focused on. Defining the epistemology can keep instructors focused on the most essential learning in a field and we found it can increase student learning (Shopkow, Díaz, Middendorf, & Pace, 2013b). As we have worked with teachers on individual classes and lessons, we have increasingly realized that we are clarifying the underlying epistemologies of different fields. This emerges very clearly from cross-disciplinary discussions. Perhaps we can't (in the beginning) describe the kinds of knowing in our fields, but when we see yours across the room, which might be very different from ours, perhaps somewhat similar, or maybe even largely the same, our own ways of operating and the epistemology our fields (the mechanisms of thought that produce the characteristic knowledge and meaning within a discipline) become clearer to us. These also emerge when we look at significant bottlenecks.

Individuals or Teams? Sharing or Not?

From what we have said above, it should be clear that we have found collaborative work to be a forceful way to apply the decoding model to improve student learning. In our workshops, we tend to form teams of three individuals from different disciplines, keeping the same teams for most of the exercises, because team members familiar with one another's bottlenecks are in a good position to generate appropriate analogies, practice exercises, and assessments that fit the mental actions.

We have run such groups for half days over two weeks; for 3-eight hour days; for a year (or two) with once-monthly meetings; and for as little as half a day or a couple of hours. When we are working within a short time frame, we focus on Steps 1-3 (bottlenecks, decoding, and modeling, usually in the form of analogies). When we have a little more time we will add in Step 6. When we have longer periods of time, we are able to have faculty fully develop their bottleneck lessons and assessment plans. When we meet over longer time frames, faculty collect iterative assessments and review them with their teams, making adjustments to the bottleneck lessons along the way.

Still, we recognize that to have this kind of time is a luxury. Many faculty will have time only for a workshop, in which case, the rest of the process may have to be pursued individually. In addition, many faculty members would prefer to work alone and it is possible to use decoding successfully on one's own. We also recognize that faculty may wish to work in informal groups, without an educational developer or facilitator present. Finally, some faculty will choose to join a more formal faculty learning community, led by a facilitator. Throughout this book, therefore, we have provided guidance for all three circumstances.

In the same way, we think that sharing what one has learned is an excellent way to clarify for

oneself what one has learned and to master it fully. Not for nothing did the medical profession used to say, "Watch one, do one, teach one!" Sharing is the logical extension of our role as teachers. This kind of sharing can be very informal. In fact, if you are working in a group, whether formal or informal, you are probably already sharing what you are learning. But sharing in a more formal way closes the gap between teaching and research, clarifying that these are indeed related activities. One of the reasons for founding the Scholarship of Teaching and Learning (SoTL) was to serve as a base in the disciplines and to bridge the gap between teaching and research (Boyer, 1997).

However, many faculty members will want to apply decoding without sharing, wishing only to become scholarly teachers. This too is an excellent thing, and we intend this book to provide many ideas about how to apply one's classroom research short of sharing it.

Decoding Beyond the Disciplines

While Decoding is a highly effective methodology for improving student learning, we do not see it as standing alone. There is a large literature about teaching and learning available at all of our fingertips these days. The problem for teachers is figuring out what applies. Teachers often adopt a teaching tip or approach and then are disappointed that it doesn't work well for them. While the problem may be that the teacher has not fully understood how to implement the technique, it may also be that the technique was ill-suited to what the teacher was trying to do. When teachers have a clear notion of what kind of thinking they want their students to do, they are better able to sort through all of the possible assessments and techniques written about in the literature.

However, the other reality of teaching is that teachers are not artisanal workers. They do not teach any given student everything from the introductory course through the capstone. This

teaching is done across departments. Similarly, in American education a student's disciplinary work is likely to be no more than a third of his or her coursework. Departments and universities are systems. Decoding can be very useful in promoting effective curriculum design within departments and discussions of student learning across institutions. This book is also intended to offer a sense of where decoding can fit into larger structures.

The Chapters

Each of the chapters in this book includes exercises at the end to show teachers how to bring students into the critical thinking that comprises their discipline. We have provided at least one exercise that can be done individually and one that can be done in a group (whether formal or informal). We have provided examples from many disciplines. You may find examples from your own discipline useful, but examples from disciplines different from your own may help you learn the Decoding the Disciplines processes by seeing the methods without being drawn into the content. In addition, seeing how someone else's discipline thinks is very helpful in clarifying what is specific to your own. Finally, we offer two examples of a bottleneck lesson, one for a scientific discipline and one for a humanities discipline, to model how one might create such a plan for oneself. These two lesson plans appear as Appendix 1. As Appendix 2 we provide a blank template for readers to use themselves.

The bottleneck, the term the decoding methodology uses for the places where students get stuck, is the subject of chapter 1. In this chapter we show how to identify significant bottlenecks in your students' work and how to select a good bottleneck to focus on. Experts can do many things quickly and at once. Bottlenecks show us where the expert thinking needs to be decoded

so that the novice can be brought into that kind of thinking. The goal of this chapter is for you to identify a good bottleneck to decode.

In chapter 2 we turn to the actual decoding step, figuring out what experts do or students might do to avoid getting caught in the bottleneck. Here we provide several different methods for decoding, depending on whether you are working alone or in a group. We show how individuals can use modeling of objects, rubrics, a reflective writing process, and analogies to decode and explain how to conduct a decoding interview for people working in groups. The goal of the second chapter is for you to have clarified the mental actions—the components of critical thinking in your field—that your students need to master in order to progress through your bottleneck.

Simply being told about a mental action isn't enough for most students to learn to do it. In chapter 3, we discuss how to model the mental actions for the students, rendering the action clearer to the students. We pay particular attention to how to develop and use analogies, which we have found help students see which "mental muscles" this mental action takes.

Once students have seen a demonstration of the kind of thinking they need to do, they need to practice it. Chapter 4 explains the process for matching the mental action to teaching methods for different types of mental moves. We will also discuss the feedback students need to direct their improvement efforts and the value of iterative practice with that feedback in mind.

When students are asked to use new (to them) disciplinary forms of reasoning, they can resist and revert to methods they are used to. In addition, some of the material and even some of the subjects we teach have an emotional resonance that gets in the way of student learning. Chapter 5 explores two different issues. First, we discuss emotional bottlenecks, which often point to areas where the categories students bring into the classroom conflict violently with disciplinary

constructs. Second, we discuss methods to hold students accountable for doing the work in the modeling and practice steps that will ensure that the students get used to new mental habits. By designing final assignments that make use of social pedagogies teachers can organize their courses in ways that undercut students' earlier habits (e.g., regurgitation of content, just going through the motions, or not doing the work) and reduce the likelihood of their reverting to ineffective learning behaviors.

Chapter 6 explains how to assess student mastery on the mental action. While in many ways, the assessments faculty do to determine how well their students have negotiated the bottleneck look a lot like the practice the students have done, we have further suggestions about what faculty can do with their results.

Chapter 7 addresses the issue of what teachers can do with their results if they choose to share them. Faculty may wish only to apply their results to their own classroom as a form of action research, but we suggest some ways of reflecting on that experience. They may also wish to present their findings informally or formally, orally or in writing and we discuss the ways of benefitting from the feedback and support of belonging to a teaching community. In this chapter, we also explore systems thinking and planned change to bring about educational transformation beyond the individual classroom, including for curriculum design and program assessment.

Though the research on teaching and learning is embedded in every chapter, chapter 8 situates Decoding the Disciplines in relation to the larger field of the Scholarship of Teaching and Learning and its relation to specific research and theories—cognitive science, troublesome knowledge, epistemology, threshold concepts, backward course design, and signature pedagogies. We also show decoding as a natural partner for SoTL and demonstrate its function vis à vis teaching innovations and pedagogy courses.

Decoding the Disciplines is a pedagogical theory about how to bridge the gap between novice and expert thinking and a 7-step methodology for teaching to bottlenecks—the places where students get stuck on their way to expert thinking. Together the bottleneck and assessment perspective can help teachers in any field become learning-centered and invested in the learner's journey. By helping students get through even one bottleneck, we can help them better understand the nature of a discipline. Beyond the individual classroom, decoding can be applied to curricula, departments, and institutions, and fields. While decoding is not a cure all, if it has to do with learning, decoding can usually provide a useful frame.