

Decision-Based Learning

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Decision-Based Learning: An Innovative Pedagogy that Unpacks Expert Knowledge for the Novice Learner

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List of Abbreviations/Acronyms

ABET	Accreditation Board for Engineering and Technology
ACRL	Association of College and Research Libraries
ALA	American Library Associations
ANOVA	Analysis of Variance
ASA	American Statistical Association
CFA	Confirmatory Factor Analysis
COAST	Collect, Organize, Analyze, Solve, and Think
DBL	Decision-based learning
DDDM	Data-driven Decision-making
EDM	Expert Decision Model
EIME	Educational Inquiry, Measurement & Evaluation
GAISE	Guidelines for Assessment and Instruction in Statistics Education
GPA	Grade Point Average
IP&T	Instructional Psychology and Technology
JiTT	Just-in-Time Teaching
PIL	Project Information Literacy
SEM	Structural Equation Modeling
SPSS	Statistical Package for the Social Sciences
STEM	Science, Technology, Engineering, and Mathematics
TA	Teaching Assistant

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Editors' Biographies

Nancy Wentworth (Emeritus) served as the Director of the Center for Teaching and Learning at Brigham Young University (BYU) and the former Chair of the Department of Teacher Education in the McKay School of Education. She was the Associate Dean in the McKay School of Education where she authored the TEAC Accreditation document for the Educator Preparation Program at BYU. Her research interests include technology integration in inquiry learning, and accreditation of teacher education programs. She has co-edited two books and authored several book chapters and articles. She retired from BYU in 2018 after 26 years of teaching, researching, and administrative work.

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Introduction to Decision-based Learning

Kenneth J. Plummer

This book provides a starting place for faculty interested in using decision-based learning (DBL). DBL is a promising pedagogy designed to catalyze novice-to-expert learning. Whether theoretician, practitioner, or both, we hope that there is something for all groups in this book who are looking for a way to better catalyze student learning in their courses, units, schools, colleges, universities, or in corporate training. As you read through the chapters that interest you the most, we encourage you to take note, of how you might adapt DBL to your teaching and/or research goals.

In Chapter 1, Dr Richard H. Swan discusses the literature on the development of expertise and the need for a focus on a type of knowledge called *conditional knowledge*. Simply put, conditional knowledge is the knowledge of *when* concepts, ideas, procedures, etc. are relevant in performing given task(s). Dr Swan includes a review of other more familiar knowledge types that function in the practical world under the direction of conditional knowledge. He asserts that the development and use of these knowledge types constitute *expert knowledge*. With this foundation in place, he discusses the importance of instructional strategies for the development of what we call a conditionalized schema or the interconnected decision-making process used to solve a vast array of problems. He articulates the limitations of contemporary instruction including deductive and constructivist pedagogies. He further discusses the impact this kind of learning can have on students affectively or in terms of their self-concept as it pertains to their decision-making abilities with the content.

In Chapter 2, Kenneth J. Plummer describes the genesis and development of DBL as described in this book. In addition, he outlines the process he uses to help faculty/experts explore their own thinking process, to discover their expert blind spots, and use DBL to create learning experiences that fill in learning gaps created by these same expert blind spots.

Chapters 3–12 are narratives of faculty members teaching courses from a variety of content areas. As the instructional designers of DBL, we have our own idealized notion of how a DBL lesson, unit, or course should be designed but as experienced faculty members begin to use DBL in their courses various natural constraints create differing types of implementation. These factors include the

stage of DBL development of a course and the degree to which our design recommendations fit within an instructor's existing approach to teaching. The authors of Chapters 3–12 report their journey designing, implementing, and evaluating the use of DBL pedagogy in their courses. Table Introduction.1 is a summary of the chapters' information including discipline category (business, social science, STEM, and writing), course content (chemistry, information systems, mechanical engineering, qualitative inquiry, religion, statistics, and writing), academic level (graduate and undergraduate), instruction type (blended, F2F, and online), class size (15–250), number of semesters implemented (1–10), research data collection (performance and survey), and academic reporting of authors' research on DBL (conference presentation and publication). This table can be found at the end of this book introduction.

A final chapter explores the common themes and lesson learned from implementing DBL including issues and effectiveness as evidenced by the experiences presented by the authors of the narrative chapters. We analyze the narratives looking for the value that using DBL brought to the instructors as they rethought teaching their content area. We explore the challenges for the instructors and the students. We summarize the lessons we learned in this qualitative analysis so that instructors beginning the process of using DBL have a sense of where to start, what aspects take the most time and bring the most value, what to expect from the students as they engage in a unique learning experience, and what methods of assessing students seem most effective.

Preview of Narratives

Chapter 3

Authors: Lane Fischer, PhD; Kenneth J. Plummer, PhD; Heidi A. Vogeler, PhD; and Sara Moulton, PhD

Title: I Am Not A Real Statistician; I Just Play One on TV

Content area: Statistics

Summary: This DBL statistics course has gone through eight iterations using DBL over the course of six years. This course was the first course to experiment using DBL back in 2014. The instructors began by implementing the approach without DBL software and in the last several years have implemented the approach with the software. Several instructors have taught this course bringing their unique styles and teaching predispositions to the DBL structure. The course is more unique among DBL courses in that the decision model encompasses almost the entire semester of instruction. More typically DBL implementation may occur periodically or during a specific unit or lesson within the course. Initially the students enrolled in this course were from graduate education programs. In recent years, graduate students from TESOL, micro-biology, dietetics, and other programs have enrolled in the course to improve their functional abilities with statistics.

Chapter 4

Author: Rebecca L. Sansom, PhD

Title: Make Thinking Explicit to Support Student Learning

Content area: Chemistry

Summary: The author of this chapter was one of the first to use a smaller decision model that did not cover an entire course but two lessons within a unit of instructions. This was an undergraduate course of roughly 200 students. She compared test results on six heat and enthalpy problems across two semesters she taught. Instead of using the software she used a PowerPoint presentation that combined a visual depiction of the decision model along with problems. The results showed a significant difference in performance that favored the DBL group. Student comments were mostly positive about the experience. This author explains that DBL leverages student skill at identifying the underlying features/structure of a problem and satisfies students' desires to know which equation to use, while reinforcing and framing those decisions using key disciplinary concepts.

Chapter 5

Author: Steven G. Wood, PhD

Title: Creating an Expert Decision Model Designed to Improve Student Learning in First-year General Chemistry Courses

Content: Chemistry

Summary: Unlike the previous chapter this author created a decision model that covered the entire course. He plans on fully implementing the DBL approach in upcoming semesters. His experience is unique in that while he has not used the DBL approach as explicitly as the other authors in this book, the principles of DBL have dramatically influenced his teaching. He describes the depth and breadth of this influence in the same introductory chemistry course level as his colleague who we introduced in the previous paragraph.

Chapter 6

Author: Todd G. Nelson, PhD

Title: Exploring Decision-based Learning in an Engineering Context

Content area: Mechanical Engineering

Summary: In this mechanical engineering course, two smaller expert decision models were used to facilitate the mastery subtopics in the course. The first model was used for the first two weeks of the course to provide a thorough review of topics from a prerequisite course typically taken during the junior year, Strength of Materials. A mastery of this material was deemed critical to the success of students in performing analysis of machine elements and in the learning of more advanced techniques for machine design. The students were assigned to work through a review set of

problems using the model. The intent of this practice was not only to review topics, but also give students a strong understanding of where the topics from the prerequisite course fit into what they have learned over the past three years as engineering students and where it fits in this course (a strengthening of conditional knowledge).

Chapter 7

Author: Degan Kettles, PhD

Title: Decision-based Learning in an Information Systems Course

Content area: Information Systems

Summary: The author of this chapter was concerned that his course, “Systems Analysis and Design,” had been traditionally taught as a series of techniques. Students learned these techniques but not the conditions in the real world that would suggest or trigger their use. As is the case with several other authors’ models in this book, his decision model did not fan out like other decision models (see Fig. 7.3) but looks more like a straight line. This occurs when, regardless of the option students choose at one decision point, both options will lead to the identical subsequent decision point. The author describes a critical feature of a DBL implementation that was missing from his course, namely, that he did not have assessments aligned with the DBL material and therefore students were not incentivized to invest in using it. He describes plans to improve implementation which as editors, we believe, illustrates the iterative nature of creating an effective DBL component of one’s course.

Chapter 8

Authors: Shiloh James Howland, MS and Ross A. A. Larsen, PhD

Title: Decision-based Learning in Multiple Regression and Structural Equation Modeling Courses

Content area: Advanced Statistics

Summary: The authors of this chapter describe two graduate level courses where DBL was implemented. These courses are generally taken in sequential order with the DBL course in Chapter 3 being a prerequisite course for both of them. The students used the software mainly during the first half of the course. Their decision models were the first to incorporate the idea of looping. Looping is a feature within the DBL approach where students can check and see if certain assumptions within a problem or data have been met. If those assumptions are not met the decision model permits students to either end their analysis at that point or perform a transformation on the data. Once the transformation is complete, students must check the assumptions on the new transformed data set. This required that decision model loop back on itself to permit a rechecking of assumptions. The professors reported that the stepwise integrative nature of DBL made it possible for students to successfully navigate which traditionally has been a very complex process for them.

Table Introduction.1. Features of Narrative Chapters 3–12.

Chapter	Discipline Category	Course Content	Academic Level	Instructional Type	Class Size	Number of Semesters Implemented	Research Data Types	Academic Reporting
3	STEM	Introductory Statistics	Graduate Students	All three	50	10	Survey	Conference Presentation
4	STEM	Introductory Chemistry	Undergraduate Students	F2F	250	1	Performance and Survey	Conference Presentation and Publication
5	STEM	Introductory Chemistry	Undergraduate Students	F2F	250	1	None	Conference Presentation
6	STEM	Mechanical Engineering	Undergraduate Students	Blended	30	3	Survey	Conference Presentation
7	Business	Information Systems	Undergraduate Students	Blended	150	1	Survey	Neither
8	STEM	Advanced Statistics	Graduate Students	Blended	20	3	Survey	Neither
9	Social Science	Qualitative Inquiry	Graduate Students	Blended	15	2	Survey	Conference Presentation
10	Social Science	Religion	Undergraduate Students	Blended	Each class was approx. 50-60 students	3	Survey	Conference Presentation Publication
11	Writing	Introductory Writing	Undergraduate Students	Online	30	1	Performance and survey	Conference Presentation
12	Writing	Advanced Writing	Undergraduate Students	Online	100	4	Performance and survey	Neither

Chapter 9

Authors: Michael A. Owens, PhD; Emily R. Mills, MS

Title: Using Decision-based Learning to Teach Qualitative Research Evaluation

Content area: Qualitative Inquiry

Summary: In this chapter, authors present a unique approach to using DBL for building the analytical and evaluative skills of students new to research. Specifically, they outline a process for using DBL to teach master's and doctoral students in qualitative research courses how to evaluate qualitative research articles and develop their own skills at communicating their own research design choices. For many of the DBL courses instructors will pose problems that range from one sentence to a paragraph length. These authors presented students with full length research articles that were annotated based on where students were in the decision model.

Chapter 10

Author: Stephan Taeger, PhD

Title: Implementing Decision-based Learning in an Introductory Religion Course

Content area: Religion

Summary: The expert decision model used for this course was designed to help students learn the historical content of a book of scripture conditionally. Ideally, using this approach, students would be organizing the book's major historical content by noticing patterns, organizing the information, and developing conditionalized knowledge. Approximately 110 undergraduate students were introduced to the expert decision model on the first day of a basic 100 level scripture class at a private religious university. The questions centered around the nature of the text, the spiritual and/or political leader at the time of the text, date, geographical location, and relevant historical events within the text with the hope that students would be guided to develop a rich conditional schema of this information. The author describes an implementation that used PowerPoint and then software.

Chapter 11

Author: Ana Katz, MS; Jason Godfrey, MS

Title: Using Decision-based Learning to Teach Source Evaluation in One-shot Library Sessions

Content area: Introductory Writing

Summary: The authors in this chapter compare DBL and another methodology to determine which is more effective at teaching freshman writing students source evaluation skills. This implementation was unique in that the DBL activities were

part of a 50-minute session in the library as opposed to being part of a larger course. The authors acknowledge that an ideal implementation would be for students to use the decision model outside of the 50-minute session in an integrated way in their regular writing courses. This chapter highlights lessons learned that can inform the breadth and depth of DBL implementation in like courses.

Chapter 12

Author: David S. Pixton, ME

Title: Information Literacy and Decision-based Learning

Content area: *Advanced Writing*

Summary: This author implemented DBL under the same conditions as Chapter 11 authors. However, this training session was with third year engineering as opposed to first year freshmen writing students. The author considered the various decision points involved with each step and built a model from there. This process was straightforward; however, at a few points in the process the author encountered situations where the order of decision points was not clear because of interdependencies between the steps. His initial choice of ordering turned out to be less ideal as scenarios were written and applied. For this reason, in future iterations he found it helpful to consider scenarios in tandem with building the model. He found the ability to loop and make the scenario adapt to the progress within the decision model quite useful, particularly since research activities are iterative.

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Chapter 1

Why Decision-based Learning is Different

Richard H. Swan

Abstract

In the early 1900s, Alfred Whitehead argued that the goals of educational reform would be met if knowledge were made functional rather than simply rearranging or privileging different forms of “inert” conceptual knowledge. And for knowledge to become functional it must be “conditionalized.” Decision-based learning (DBL) is different because it explicitly conditionalizes learning and makes knowledge functional. Moreover, DBL fits within an overall developmental progression of expertise and fills a gap often overlooked by formal education. Considerations for designing and implementing DBL are outlined.

Keywords: Conditional knowledge; developmental progression of expertise; expert blind spot; decision-based learning; expert decision model; just-enough, just-in-time instruction

In 1929, Alfred Whitehead published a set of essays on education in which he observes yet another educational reform movement (specifically in Great Britain) promising to do better than previous reform movements. Yet, Whitehead (1929) argued that this movement too was overlooking the real underlying problem – that students were still being stuffed with “inert knowledge” (p. 1). To make a difference, he claimed, knowledge must be made useful, or in his words, “conditionalized” (Whitehead, 1929). All the debate and activity of educational reform would merely swap one form of inert knowledge for another.

Now, almost 100 years later, Whitehead’s critique sounds contemporary. In *How People Learn*, Bransford et al. (2000) cite Whitehead and note that expert knowledge is conditionalized; yet they do not argue that formal education helps

to conditionalize knowledge. Walsh and Kotzee (2010) went further, noting that higher education focuses primarily on conceptual knowledge, “but students have had to develop the conditional knowledge which is necessary to achieve fully functioning knowledge *on their own after graduation*” (p. 40, citing Biggs (2003), emphasis added). It seems that we are still playing an educational shell game – constantly rearranging the same shells, thinking this time we will find the prize. Yet, something still seems to be missing; students still seem to be underprepared for entry into their careers (Biggs, 2003, 2011; Swan et al., 2020; Walsh & Kotzee, 2010).

In my lifetime, reform movements have arisen, some have lingered, most have faded. Promises of revolutionizing education through computers, the Internet, games in education – like previous promises about film, radio, and television – have failed to live up to the hype. To be sure, there are new affordances that are positive, but overall, I see little difference from when I was a student decades ago to today. Even now, with more than 20 years as a faculty developer, I still observe that teachers worry most about content and coverage while students still exhibit the same compliant yet unengaged, when-can-I-be-done-and-get-on-with-real-life behavior. If that is the case, then why are we writing this book, touting yet another teaching method? – hoping, like so many others, to revolutionize education?

Decision-based learning (DBL) is different; it does not merely rearrange the shells. At a minimum, it answers Whitehead’s call and makes conditionalizing knowledge a first order learning activity. But why is conditionalizing knowledge important? We submit that conditionalizing knowledge fits within an overall developmental progression of expertise.

The Developmental Progression of Expertise

Since the Middle Ages, the terms *apprentice*, *journeyman*, *expert*, and *master* have been used to designate levels of expertise. In short, the apprentice is a beginner who is learning the craft. The journeyman is competent enough to be sent out to do a job unsupervised (he can journey on his own). The expert has developed superior abilities and can train others in the craft. The master is the experts’ expert and can also extend knowledge in the discipline (see Hoffman, 1998, 2016; Swan et al., 2020).

The names of these levels do little to describe the nature of the expertise achieved. Swan et al. (2020) make a case that levels of expertise can be explained in terms of knowledge types (procedural, conditional, and conceptual) and fluency within and between knowledge types. In other words, progressing from one level of expertise to another requires competence in a different knowledge type. This argument, summarized below, provides a theoretical foundation for DBL.

Knowledge Types

One way to classify knowledge is as *procedural*, *conditional*, and *conceptual*. Procedural knowledge comprises the tasks, checklists, algorithms, order of operations, equations, etc. of the domain. It requires execution but little reasoning (Bransford et al., 2000; Hatano & Inagaki, 1984; Swan et al., 2020). Conditional knowledge answers the question: “When does this apply?” It enables the ability to recognize and focus on salient characteristics of real-world situations that

activate relevant knowledge and action while less relevant characteristics and knowledge remain in the background (Bransford et al., 2000; Swan et al., 2020). Conceptual knowledge comprises the abstract ideas, patterns, models, and theories of the domain. Conceptual knowledge allows a person to reason about a situation using general principles; these general principles facilitate adaptivity and creativity when approaching novel or complex situations (see Dreyfus & Dreyfus, 2008; Swan et al., 2020).

Relationship of Levels to Knowledge Type

These knowledge types correspond well with levels of expertise (see Swan et al., 2020). The apprentice begins by learning the procedures of the field and requires direction as to when to use these procedures. The journeyman adds to procedural skill the recognition of situational conditions that call for specific procedures, and therefore can function independently. The expert can reason conceptually about atypical or complex situations and can adapt their response accordingly. The master may reexamine and extend the procedural, conditional, and conceptual knowledge of the field. As individuals add to, and gain fluency with, these knowledge types, their expertise increases.

More than just levels, they also imply a developmental progression. The development of expertise is not a matter of some innate superiority of talent or intelligence; nor is it simply a matter of accumulated experience and practice (Ericsson, 2017; Sternberg, 1999). A person can remain at a given level of expertise for years and never progress to the next level (Hatano & Inagaki, 1984; Hoffman, 1998, 2016). To advance, individuals must incorporate a different knowledge type (Swan et al., 2020).

By understanding the role of knowledge types in the development of expertise, we can be more intentional about the growth of expertise in our students. We can approach expertise structurally through knowledge types and fluency rather than assuming that those who “get it” are naturally more intelligent than those who do not. More specifically, we can explicitly incorporate conditional knowledge in the sequence. Such an approach requires a different conception of expertise as shown in [Table 1.1](#).

The correlation of knowledge type to expertise supports Whitehead’s critique from a theoretical position as well as confirming more recent research regarding conditional knowledge (see Amolloh et al., 2018; Endsley, 2018; Fadde, 2009; Kallio et al., 2018; Kirschner et al., 2006; Raymond, 2019; Sansom et al., 2019; Sugiharto et al., 2018; Turns & Van Meter, 2011; Walsh, 2007). One might ask, “If conditional knowledge is so important, why has it been overlooked?” One plausible answer is “the expert blind spot.”

The Expert Blind Spot

Consider this general narrative which does not seem uncommon: a person attends higher education. They learn some procedural knowledge and a lot of conceptual knowledge that is largely disconnected (see Anderson et al., 2001; Ostermann et al., 2018). Although they still feel inadequate for their career, they graduate

Table 1.1. Levels of Expertise Corresponding to Knowledge Types Adapted from Swan et al. (2020).

Levels of Expertise	Description
Procedural expertise (Apprentice)	Able to execute <i>procedures</i> skillfully when directed, but unable to function independently
Functional expertise (Journeyman)	Able to recognize the relevant <i>conditions</i> of a concrete instance and <i>select</i> and execute an appropriate procedural response; thus, able to function independently
Adaptive expertise (Expert)	Able to reason <i>conceptually</i> about the nonstandard, novel, or complex situation and adapt established procedures for an appropriate response
Generative expertise (Master)	Able to recognize the failure of the status quo to account for the novel or complex instance. Able to pursue functional investigation of novel responses to the novel or complex instance which often results in knowledge generation. Thus, reasons reconstructively <i>within</i> , and analogically <i>outside</i> , the domain to expand procedural, conditional, and conceptual knowledge in the domain

(see Walsh & Kotzee, 2010). They continue in the field and as they gain real-world experience, suddenly they see how concrete conditions relate to the concepts they were taught and – ah hah! – they see how it connects. “So that’s what my teacher was trying to tell me!” As they encounter more situations and insights, they will develop a robust conditional schema, but it will have been acquired tacitly and unsystematically.

Some of these persons will become teachers. The concepts that now have so much meaning will become prominent. Indeed, their eureka moments seem to elevate conceptual knowledge as enlightening and diminish the conditional knowledge which enabled that enlightenment. Further, conditional knowledge has become so entangled with conceptual knowledge that any connection seems inherent, obvious, and intuitive (Bransford et al., 2000; Endsley, 2018; Swan et al., 2020). Consequently, conditional knowledge recedes from conscious awareness.

This phenomenon has been aptly dubbed “the expert blind spot” (Catrambone, 2011; Nathan et al., 2001; Nathan & Petrosino, 2003; Petrosino & Shekhar, 2018). According to Tofel-Grehl and Feldon’s (2013) meta-analysis, experts (teachers) think they are explaining comprehensively, yet unconsciously omit from 40 to 70% of the knowledge novices would need to replicate what they do (see also Feldon, 2010; Foley & Donnellan, 2019; Hoffman, 1998). Of course, what seems to be overlooked is conditional knowledge (Cardenas et al., 2020; Swan et al., 2020). To the new instructor, the challenge of teaching still seems to be how to do a better job explaining concepts. And so, the cycle perpetuates itself.

Wood (this book) argues that conceptual knowledge is incomplete without the interconnected conditional and procedural associations. Conditional knowledge is necessary to be functional, but it also lays an essential foundation for conceptual understanding. Thus, as educators, we must be more aware of the learning progression and situate conditional knowledge within instruction where appropriate. For most of us, that means we must uncover the expert blind spot making conditional knowledge visible to ourselves and our students. The process of designing for DBL does just that. The pedagogy of DBL uses the resulting conditional schema as the driver for instruction until a degree of functional fluency is achieved. When learners become and feel competent—and see the functional value of their knowledge—they are primed and ready for the conceptual conversation. In fact, they often initiate it.

We do not want to tout DBL as the be-all and end-all of education. DBL situates conditionalizing knowledge in its proper sequence to develop a degree of functional expertise within an overall developmental progression. In some cases, functional expertise suffices. Where adaptive or generative expertise is desired, the DBL experience lays a solid and necessary foundation for continued growth. Consequently, there are courses where DBL may not fit; there are courses where DBL may be most or all of the course; and there are instances where DBL will be some fraction of the course.

That leads to the question, “How do we help students conditionalize their knowledge?” To answer that question, we must consider DBL as a design method and as a teaching method. (As you read succeeding chapters, look for examples and non-examples of the structures we lay out below.)

DBL as Design Method

From a design perspective, DBL employs a backwards design approach (see Wiggins & McTighe, 2005). Thus, the first step is to define a functional learning outcome. By functional, we mean something that includes the general area of *apply, analyze, or evaluate*. Each DBL unit focuses on a single learning outcome. A given learning outcome may represent a substantial portion or smaller portion of the course. DBL may be appropriate for one or multiple learning outcomes. The scope of DBL in the course depends on the learning outcome(s). Using that functional learning outcome, DBL adds these design elements:

- An expert decision model (EDM).
- Just-enough just-in-time instruction.
- A well-populated bank of conditionally organized problems or scenarios.

The EDM

Essentially, an EDM is a map of how one expert organizes their conditional knowledge to inform their decision-making process. Our experience indicates that teachers have an implicit conditional taxonomy of types of problems or scenarios. To reveal that structure, DBL uses a form of cognitive task analysis

(see Gordon & Gill, 1997). By systematically walking the teacher through their decision-making process for the range of problem types, the structure of their conditional knowledge, or conditional schema, begins to reveal itself. This conditional schema is represented as an EDM. DBL does not propose that any EDM is definitive. Different experts will have some variation in how they perceive their discipline; thus, an EDM represents that expert's approach.

An EDM is the backbone of DBL instruction. Each point in the model represents a decision. Models may be branching (different conditions lead to different decision points), linear (the same decision points will be traversed but the resulting set of conditions will be different), looping (the process repeats until a condition is met), or a combination thereof (see examples in succeeding chapters). Decisions about which concepts or procedures apply hinge on the conditions present in the situation. Thus, acquiring conditional knowledge at each decision point provides an opportunity for learning and/or activating relevant conceptual and procedural knowledge. Each decision point, then, represents an opportunity for instruction. However, the nature of the instruction should be carefully considered.

Just-Enough, Just-in-Time Instruction

It is almost an inexorable gravitational pull to teach all the wonderful things we know when the opportunity arises. Yes – it is true that it is all important. Yes – it is true that they will need to learn it eventually. But, it is also true that this “firehose” approach leaves learners overloaded and confused. In any form of instruction, we need to have the discipline to give them what they need when they need it.

DBL provides an excellent vehicle for targeting instruction to the need. As mentioned above, each decision point is an opportunity for instruction. The essential property of this instruction is that it contains just enough information just in time to make the current decision, in other words, just-enough, just-in-time instruction. Learning modules at each point should be surgical; anything unnecessary should be removed.

Well-populated, Conditionally Organized Problem or Scenario Bank

Typical instruction tends to show learners how to handle each problem type in isolation. Within DBL, however, students learn to recognize problem types in relation to similar problem types. At each decision point there is a minimum of two conditions. They learn to recognize conditions in relation to sibling conditions and how these conditions affect the outcome. Thus, they are learning not just in context but in relation to other possible contexts. With sufficient repetition through the different problem types, students see how situations are related yet different; a conditional schema begins to form.

Sufficient repetition requires a well-populated bank of realistic problems or scenarios for students to practice with. These problems should represent the range of, and must be categorized by, conditional variations. Again, experience indicates that there is a taxonomic organization of problem types that already

exists even if tacitly. The EDM should expose these conditional variations. A little extra attention is then required to create a robust set of problems that account for each variation. Creating a well-populated problem bank is not hard but may be time consuming. But it is also essential to help learners develop a degree of functional expertise.

DBL as a Teaching Method

Where DBL is appropriate, we find it essential to follow the DBL teaching method for that portion of the course. In other words, DBL is not a complementary add-on, or a helpful exercise for existing practice; it needs to be the form of instruction for that unit. The essential elements are listed below in order of importance which puts them in reverse chronological order.

- Frequent, interleaved, and no-scaffolding assessment.
- Self-directed and variable-scaffolding practice.
- High scaffolding and problem-based interaction.

Frequent, Interleaved Assessment

By its nature, DBL is highly scaffolded and students will over-rely on the structure unless they are required to perform without scaffolding early and consistently. Small, frequent assessments provide the means for students to be accountable for internalizing the conditional schema. In addition, problems from earlier learning should reappear routinely in subsequent assessments (interleaving).

DBL can use the familiar forms of assessment such as multiple choice, short answer, papers, etc. However, these assessments require students to use conditional knowledge. We have found some interesting ancillary benefits from DBL assessments. First, students cannot cram, nor can they rely on test-wiseness. Yet, so far, any student who is willing to put in a reasonable amount of practice performs well on the assessment. Students who think they can finagle the assessment and get by (as they have in other classes) mostly fail. There is little middle ground. Students learn quickly that they must put in the work to learn.

Second, while the initial motivator might be the assessment, students begin to see that they are becoming competent; they understand what they are doing, why they are doing it, how it fits together, and how it applies to the real world. Their self-confidence increases and worries about grades recede. Their learning becomes self-motivated and largely self-directed. We should note here that DBL destroys a normalized grade distribution. And not because the course is not rigorous; it is because the hard work pays off. And after all, isn't the goal of teaching to help every conscientious student succeed?

Self-directed, Variable-scaffolding Practice

As mentioned above, mastery requires systematic practice. Thus again, the need for a robust problem bank. With a well-populated problem bank, students have

ample opportunity to practice. Because students know that an assessment is around the corner, they know, and do, wean themselves off the scaffolding. The scaffolding is still present if necessary, but students can vary the amount of practice and scaffolding to suit their own learning needs. Students become capable of regulating their own learning. The teacher becomes a secondary resource for occasional guidance, clarification, and expansion.

High Scaffolding, Problem-based Interaction

High scaffolding is provided by walking students stepwise through the decision points of the EDM with just-enough, just-in-time instruction. This interaction can occur either in-person or online. In both cases, students are given a realistic problem or scenario. They are presented with the first decision point. Usually, they do not know how to decide. They are given (or access) the learning module which gives them just-enough, just-in-time instruction.

Looking again at the problem, many students are able to make the appropriate decision for the situation though not all. In person, the teacher may ask a student to defend their answer. The discussion about why the selection is the best answer helps clear up misconceptions and cement student learning. In addition, the problem may contain more than one cue that the condition is present. If students do not recognize all the cues, the teacher may also point them out. In an online approach, students make a decision and the software gives them immediate feedback. They also have the option to review the learning module or to view an expert's model response and compare that response to their own. With satisfactory performance at that decision point, instruction moves to the next decision point and the process repeats itself until the final decision for that problem is made. Students have completed one instance of accomplishing the learning outcome.

This level of scaffolding is only necessary as an introduction. It may be helpful to provide high scaffolding at the beginning of new problem types or new units. Sadly, however, for those of us who feed off the energy of classroom interaction, once students are accustomed to taking problems through the EDM, they no longer need nor desire much direction. The teacher is not superfluous, however, they will still rely on you for coaching, guidance, clarification, and expansion of their understanding. But the satisfaction of a job well done does come from seeing students engage, take charge, and watching them grow in competence and confidence.

Conclusion

In short, DBL fills a void in formal education. While it is important in its place, it is not for every learning outcome. As functional fluency is achieved, the need for DBL diminishes. We are often asked: "Does it work for every discipline?" Our response: DBL is a good fit for any situation in which students should learn to analyze, synthesize, and/or evaluate. That seems to be part of every discipline.