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On Oceans and Skies: The Depth and Breadth Problem in Science Education

In the old rock and roll song, Petula Cark lyrically characterizes her love as deeper than the deepest ocean and wider than the sky. Love may be one case where depth and breadth are connected and in synchrony. But in science classrooms, instructional depth and breadth often seem as irreconcilable polar opposites. It seems as if one has to choose to teach students the foundational concepts and causal beliefs of a discipline (deeper than an ocean) or the wide range of related phenomena and issues making up the discipline (wider than the sky). Understanding and resolving this apparent conflict between teaching for curricular breadth or conceptual depth is the source of my vexation. My venture has been to look for ways to reconcile, not merely balance out, the goals of instructional depth and breadth.

Vexation

The challenge posed by teaching for conceptual depth vs. curricular breadth is widely recognized. For example, the NRC's 1996 National Science Education Standards readily acknowledges the issue:

> *Different students will achieve understanding in different ways, and different students will achieve different degrees of depth and breadth of understanding depending on interest, ability, and context. But all students can develop the knowledge and skills described in the Standards, even as some students go well beyond these levels. (p. 2)*

The NSES addresses the issue of instructional depth and breadth by suggesting that there is an appropriate balance between them which optimizes student learning. But for any given teacher in any given classroom, there is a decision point when time constraints demand either addressing students' misunderstandings of particular concepts or moving on to new material in order to complete the course. As a psychology professor, I have felt the tension between ensuring that students understood the conceptual issues regarding a particular phenomenon and that there would be enough time to survey all the other relevant phenomena.

At the heart of my vexation is how to reconcile pedagogical goals associated with instructional breadth or depth. This goes beyond seeking an optimal balance to exploring how to promote one goal in the service of the other. Some may object to my characterization of the problem, thinking that the two instructional goals involve antagonistic student outcomes, curricula, or teaching styles, so they cannot be reconciled. For example, some may assume that instructional depth is process-oriented, involves a project- or discovery-based curriculum, and promotes conceptual understanding over mere memory; whereas instructional breadth is content-oriented, requires a didactic curriculum, and promotes memory over conceptual understanding. Such assumptions have been empirically challenged. Memory research (Craik & Lockhart, 1972) suggests that conceptual understanding (e.g., grasping core disciplinary knowledge) enhances recognition and recall (e.g., performance on tests of disciplinary phenomena), suggesting that there is considerable compatibility between the instructional goals. Moreover, research shows that a traditional didactic approach to teaching scientific reasoning may be more efficient in its promotion than is a process-oriented approach, with which such a goal is typically associated (Klahr & Nigam, 2004). Similarly, evidence shows that project-based teaching strategies may be more efficient than didactic-based ones for promoting standardized test scores (Schneider, Krajcik, Marx, & Soloway, 2002).

Reconciling the goals of instructional depth and breadth, however they are pedagogically accomplished or assessed, is important to me in my role as a teacher and educational researcher. As a teacher, I don't see why I should compromise either goal as both seem central to preparing students to fully grasp a discipline. Anything less than presenting students with an account of how core knowledge of a discipline applies to the range of relevant phenomena would seem to offer a distorted view of the discipline. The trick is to define the core knowledge which can serve as a catalyst to promote the learning of a range of disciplinary phenomena. This has been my focus as an educational researcher. I have been exploring the process of conceptual change in psychology students as they progress from underclassmen with limited exposure to the discipline to upperclassmen who are majors and minors in the discipline. Their process of conceptual change reveals much about the value and importance of emphasizing both the depth and breadth of the discipline.

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Venture

My venture has been to try to reconcile instructional breadth and depth, rather than treating them as polar opposites. As a teacher, I have designed my Introductory Psychology course to not only address key disciplinary issues but to do so across the range of phenomena. It has been my experience that students enter the class seeking to confirm their belief that behavior is largely under conscious, rational control (D'Andrade, 1986; Wellman, 1992). Students' "folk psychology" is not unlike their "folk physics" where there is an explanatory bias favoring singular, dispositional and intentional causal explanations of the behavior of objects or people. Such a bias discourages explanations of behavior emphasizing multiple, dynamic, and interactive causes, which are presented in the discipline. In both Psychology and Physics, the introductory course is implicitly designed to present a scientific alternative to their "folk" theory, with a focus on alternative exploratory modes.

Challenging students' conceptions of human nature provides the theme for them to understand a range of discipline-related phenomena. The course begins with an outline of folk psychology to help students learn how to critically reflect upon and evaluate their theory of mind and its biased explanatory framework. Assumptions of Folk Psychology are then challenged early on in the semester with chapters that lend themselves to stark contrast between the Folk and Scientific approaches to the discipline (Learning, Biological Basis, Perception and Consciousness, Memory, and Cognition). Students are then presented with the role of multiple, dynamic, and interactive factors (from genes to culture) influencing behavior in chapters which provide clear cases of the value of such a form of explanation (Motivation, Social Psychology, Cultural Psychology, and Personality). The final three chapters (Development, Psychopathology, and Treatment) provide an opportunity to fully apply this explanation to a range of phenomena.

My research venture has also been to explore the conceptual change in psychology students' understanding of human nature. Mapping students' pathway of conceptual change provides insight into the kind of understanding of the discipline that they are acquiring. As would be expected from traditional accounts of conceptual change, only Psychology students come to embrace scientific over folk psychology compared to students in the Humanities or Science. Other findings suggest that, as expected, it is difficult for students to purge their initial misconceptions about psychology, but doing so is associated with higher course grades, evidence of higher levels of disciplinary thinking, and progression in the major. However, not all of the data support the expected rejection of a folk conception of a discipline in favor of a scientific conception. For example, students never explicitly rejected Folk Psychology over the course of majoring in the discipline. Instead they become more critical of both the Folk and the alternative conception.

The research speaks to a process of conceptual change in which students start off with a narrow conception of psychology phenomena, framed from their folk theory. However, over the course of majoring in the discipline, rather than purging their folk theory, they learn to critically evaluate any account of psychological phenomena, whether it is from the scientific discipline or their own folk intuitions.

My future venture is to more directly test the view that Introductory Psychology is most effective when providing students with the conceptual framework of scientific psychology, particularly where it conflicts with folk psychology and applies across a range phenomena. Specifically, the study will test the view that explicitly challenging students' Folk Theory of Mind with Scientific Psychology makes it easier for them to understand a range of disciplinary phenomena. The study would be in part a comparative experimental design assessing the progression of students in Introductory Psychology and Introductory Physics who are randomly assigned to a teaching condition in which they are or are not given instruction focusing on their conceptual bias in preferring singular, dispositional, and intentional over multiple, dynamic, and interactive causal explanations of the behavior. A comparison of the two groups' performance on the same standardized class tests will provide evidence of the impact of conceptual depth training on pedagogical breadth across two disciplines.