While researchers have examined how disciplinary and departmental cultures influence instructional practices in higher education, there has yet to be an examination of this relationship at the embodied level of culture. In this article we utilize cultural models theory to examine the theories of student learning and teaching practice espoused and enacted by undergraduate math and science faculty. To examine these cultural models of teaching and learning we use thematic analysis, clustering, scaling, and graphing techniques to analyze interview transcripts and classroom observation data among 41 undergraduate math and science instructors across three universities in the United States. We then focus on three individual cases of instructors to examine how their cultural models interact with other cultural models, existing forms of teaching practice, and features of instructional environments to shape their teaching practices. The article concludes by setting forth an agenda for future research and arguing that the “cultures of teaching” in these disciplines should not only be perceived as barriers but also opportunities for meaningful pedagogical innovation.

Keywords: cultural models, undergraduate education, STEM, culture, cognition, pedagogy

As we go about our day-to-day lives we encounter incredible complexity in our relations with others and our surroundings. Yet, more often than not, we move from one situation to the next without feeling the full burden of this complexity because we have constructed models—or
“theories”—of how people, events, and objects fit together. Social scientists often refer to these as cultural models because they consist of shared information and are internalized through patterns of socialization within and between groups. Consider, for example, that on the first day of a new semester thousands of students filter into lecture halls, find seats, and wait for someone to assume responsibility at the front of the room. This coordination of action occurs without explicit instructions because each student has a cultural model for how people and practices typically fit together in this particular situation. These models perform valuable social and cognitive work with tremendous efficiency, which in turn allows us to take on more complex practices. Of course, the world does not always work so smoothly—sometimes our cultural models conflict with other models, objects, and events, reminding us that cultural models are often deeply political (Gee, 2004a).

Social scientists from across the disciplinary spectrum have contributed to a rich body of literature focusing on the theoretical and applied aspects of cultural models (for a general introduction see D’Andrade, 1995). In education, researchers have drawn upon cultural models theory to describe and enhance literacy practices (Gee, 2004b), student achievement (Ogbu & Simons, 1994), and cross-cultural relations (Fryberg & Markus, 2007), among other topics. However, researchers focusing on higher education contexts have yet to fully appreciate the utility of cultural models theory. While culture theory has been used to examine the nature of faculty work in general (e.g., Austin, 1996) and teaching strategies in particular (Umbach, 2007), these applications have tended to view culture as a homogenous set of beliefs and values ascribed to a single social group (e.g., an academic department) that operates to unilaterally influence faculty behavior. However, this view of culture overlooks areas of culture theory that emphasize how norms and practices are internalized by individuals as they interact with a variety of social groups and situations, which leads to a more differentiated, contextualized, and, at times, contradictory view of culture and its relationship to action (DiMaggio, 1997; Trowler, 2008).

In this article we argue that cultural models theory is a useful tool that researchers and policymakers can use to understand and transform teaching and learning at the undergraduate level—particularly in math and science disciplines. Our emphasis on math and science faculty occurs during a time of tremendous energy and resource allocation aimed at enhancing the recruitment and retention of undergraduates in science and math majors. Researchers and educators have framed these efforts as an important component of racial and gender equity within the education system and occupational structure (e.g., Carter, 2006; Fox, Son-
nert, & Nikiforova, 2011). In addition, many argue that undergraduate science and math education is a critical factor in achieving economic vitality (National Science Board, 2010), as projections estimate that the fastest growing jobs requiring a college degree in the next five years will require extensive training in science and mathematics (Carnevale, Smith, & Melton, 2011; Lacey & Wright, 2009).

One of the principal strategies employed to achieve these goals has been to encourage science and math faculty to adopt pedagogical techniques that are grounded in research on how people learn (e.g., Bransford, Brown, & Cocking, 1999). Yet, preliminary evidence suggests that the widespread adoption of these teaching practices has not yet occurred (President’s Council of Advisors on Science and Technology, 2012), and one of the main reasons cited for this state of affairs is that the disciplinary and organizational cultures of academia represent barriers to change. Consequently, some are calling for a change in the “culture of teaching” among science and math faculty and departments at large research universities (Anderson et al., 2011; Wieman, Perkins, & Gilbert, 2010).

In the following we examine cultural models of teaching and learning in math and science as networks of cognitive schemata that are distributed between and among groups of faculty, and whose instantiation in the classroom is mediated by perceived constraints and affordances in instructional practices and environments. The construction of this argument is built around the exploration of three specific questions: (1) What cultural models do math and science instructors have for how students best learn the key concepts in their respective fields and for the most effective ways to introduce students to those concepts? (2) To what extent are these models enabled and/or restricted by instructors’ perceptions of constraints and/or affordances within their instructional environments (e.g., class size, classroom technology, and student expectations)? (3) How might our understanding of these cultural models inform the efforts to transform pedagogical practices in the math and science disciplines?

To address these questions we drew upon interview and classroom observation data collected from 41 instructors from math and science disciplines across three research-intensive universities. We began by using cluster analysis and multidimensional scaling to analyze thematic codes derived from the interviews and to explore the principles underlying these components of the cultural models. In the next phase, we drew upon classroom observation data and interview transcripts to explore the extent to which the models of three instructors guide their pedagogic decisions and practices as they are activated in specific instructional sit-
In addition, we used graphing techniques from social network analysis to illustrate the different configurations of teaching methods, cognitive engagements, and instructional technology use that constitute each participant’s classroom practice. These data are brought into conversation with the interview transcripts to demonstrate how the instructors’ cultural models of teaching and learning are enabled, mediated, and constrained at the intersections of cognition, social practice, and instructional contexts.

The results from the analysis are suggestive for those interested in undergraduate education, particularly the math and science disciplines. These findings offer researchers, instructional designers, and policymakers insights into how math and science faculty “theorize” student learning and their own role in that process. While the theoretical understanding offered here portrays a complex account of cultural practice that does not offer a single policy or leverage point to affect change, we suggest that such a nuanced view of the processes underlying educational practice and change processes is nevertheless an advance over the “silver bullet” perspective of educational transformation.

The Interface of Culture and Cognition: Cultural Models Theory

Attention to the role of culture in postsecondary institutions has a long history. One of the dominant approaches to understanding culture in academia has been to view culture as a unitary set of beliefs, values, and practices that can be ascribed to entire disciplines or institutions. This conceptualization of culture has led to the development of cultural typologies (e.g., Bergquist, 1992) through which culture is used as an independent variable in statistical analyses that predict faculty practice (e.g., Umbach, 2007). In recent years, however, researchers have critiqued this perspective of culture theory for ignoring within-group variability and faculty subcultures (Trowler, 2008), obscuring the interpretive and evolutionary nature of cultural life (Tierney, 2008), and for overlooking the subtle dynamics between individuals and the diverse contexts of academic organizations (Ashwin, 2008; Trowler, 2008). Cultural models theory—when combined with theoretical insights from sociology and cognitive psychology—provides an insightful point of departure for understanding these dynamics.

The development of cultural models theory has been guided by a desire to understand how individuals internalize, organize, and enact cultural knowledge. In particular, researchers have sought to understand how cultural knowledge is organized into cognitive structures (often referred to as “schemata”) held in long-term memory and activated in
specific situations and environments. Cognitive anthropologists define cultural models as simplified theories about relations among people, practices, and events that are developed through the repeated activation of neural networks in relation to specific tasks and situations (Quinn & Holland, 1987). These cognitive structures are distributed within and between groups and linked to (prototypical) simulations in our minds that help us assemble meanings and act upon them in social situations. While cultural models generate meanings, explanations, and practices in a similar fashion to any scientific theory, they are often implicitly held and thus difficult to articulate at a theoretical level (Quinn & Holland, 1987). However, individuals can usually offer insights into the workings of their cultural models through judgments, perceptions, and explanations of specific situations (D’Andrade, 1992, p. 34). In this sense, cultural models frequently operate as a form of practical reason (Bourdieu, 1990).

Cultural models are not fixed rules for behavior that, upon activation, immediately translate into specific actions. Instead, cultural models have a causal form that allows us to act in the world without having to fully consider all possible actions at the same time. These models assemble situated meanings on the spot, which in turn enable us to make sense of complicated processes without necessarily considering every detail (Gee, 2005). This does not mean that cultural models always generate reliable meanings or that knowing an individual’s cultural models makes his or her behavior predictable in every situation. To the contrary, cultural models are often inconsistent, incomplete, and/or exist in conflict with other cultural models.

The dynamic nature of cultural models is partly due to the fact that different models are closely linked to features of the environment, such that certain cues (e.g., a large classroom) not only activate a related network of schemata but also constitute a part of the schema itself. Research in cognitive psychology shows that environmental features are noticed and encoded based largely on our physical interactions with the world, and these embodied conceptualizations of the environment are then combined with preexisting knowledge to form memories of our surroundings (Glenberg, 1997). Furthermore, different organisms will respond to different features of their environment based on their unique needs and properties, such that some objects will be perceived as “affording” particular uses or actions (Gibson, 1986). In the same way, people can perceive objects or other entities to pose constraints to practice, or otherwise discourage a particular use or limit the range of possible actions. Individuals and groups will develop attunements to the constraints and affordances represented by objects, policies, norms,
and social regularities in a given environment, which over time can become a core aspect of decision heuristics or rules for particular tasks (Greeno, 1998). In this way, rather than perceiving culture as inhering in either public information “out there” or solely cognitive structures in the mind, a more compelling view focuses on the interactions among each of these realms (DiMaggio, 1997, p. 274).

Cultural models tend to be distributed unevenly within and between social configurations. That is, there are divisions of labor to cultural knowledge that differentiate who needs to know what. For cognitive anthropologists such as D’Andrade (1984), these social structures are aspects of the organization of cultural meaning systems—“the achievement of systematicity across persons through meanings” (p. 110). Critical theorists are likely to add that these social structures are also the means by which certain forms of cultural knowledge are maintained as scarce commodities and legitimate symbolic domination (e.g., Bourdieu, 1984). Thus, just as we rely on our cultural models to perform important cognitive work, we also rely on social structures to perform the consequential social work of dividing the cognitive labor within and among groups. There is, then, a duality between social structure and culture in which the patterning of social interactions and affiliations happens alongside differentiated cultural meanings and strategies (Mohr & Duquenne, 1997).

Thus, an examination of cultural models in any context involves understanding cultural knowledge as distributed at the individual and group levels, as well as existing at the intersections of environmental and situational contexts (e.g., classrooms), social practices (e.g., teaching strategies and interactions), and cognition (e.g., folk theories of teaching). It is at these intersections that we can gain insight into the ways that instructors’ cultural models are enabled, adapted, and even constructed in relation to constraints and affordances in teaching practices, interactions with students, and features of their instructional settings.

**Specifying Cultural Models of Teaching and Learning**

Although some researchers have paid close attention to the relationship between teaching practices and culture in higher education (Trowler, 2008; Umbach, 2007), the literature lacks a targeted analysis that connects these practices to instructors’ cultural models of teaching practice and student learning. In this article we examine instructors’ cultural models of teaching and learning through the assumptions they make about the ways students best learn the key concepts of their disciplines and the most effective ways to introduce students to those
concepts. Until now, we have considered only the general form of cultural models. In order to investigate cultural models of teaching and learning among math and science instructors it will be helpful to identify the form and functional work that these models perform as distinct from other types of models. For this task we use the conceptual typology of cultural models developed by Shore (1996, pp. 46–66).

The types of cultural models investigated below are examples of special-purpose models comprising a combination of expressive/conceptual models and task models (Shore, 1996, pp. 61–66). Expressive/conceptual models designate crucial yet often tacit information and experiences within (and sometimes between) certain communities. Among the different types of expressive/conceptual models, undergraduate instructors’ cultural models of teaching and learning can be defined more specifically under the category of theories. This type of expressive/conceptual model helps to simplify complex processes and interactions. The cultural models of teaching and learning discussed below consist, in part, of theories that range from tacit folk theories to more elaborate scientific theories, and sometimes combinations of both.

Other components of the cultural models of teaching and learning discussed below can be conceptualized as task models. As the name suggests, task models organize strategies for completing practical tasks. “Scripts” are a type of general performance task model that are commonly drawn upon (often implicitly) in instructional situations. For instance, many mathematics instructors have a script for introducing students to a new theorem. One such script proceeds as follows: The theorem is introduced and proved as an abstract form and then followed up by working through a series of example problems. Students are then assigned problem sets that require them to work through more example problems germane to the theorem. The cultural models of teaching and learning explored below each consist of a theory of student learning and a script for facilitating that learning. In practice, the line between expressive/conceptual and task models may not be so clear, but the analytical distinction is helpful in understanding the different kinds of work actually done by these cultural models.

Methodology: Analyzing Cultural Models of Teaching and Learning in Theory and Practice

Researchers interested in examining cultural models have used a variety of methodological strategies. These strategies include scaling of judged similarities and clustering of folk taxonomies (D’Andrade,
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1995), consensus modeling (Weller, 2007), as well as a variety of discourse analysis techniques (Gee, 2005). In this article we draw upon multiple tools from within and outside the cultural models literature to construct the cultural models of teaching and learning among all instructors in the study sample, and to examine how three of the instructors enact and use these models in practice. Details concerning our multistep analytical strategy are described below.

**Data Sources**

To examine the cultural models of teaching and learning among math and science instructors we draw upon data collected through semistructured interviews and classroom observations among undergraduate instructors ($N = 41$) in math, physics, chemistry, biology, and geology departments across three large research universities. As noted above, the primary concern among reformers and policymakers is transforming undergraduate STEM instruction at large research universities (Wieman et al., 2010). Thus, the three sites in this study were selected specifically because they share the following characteristics: (a) public research-intensive institutions as defined by the Carnegie Foundation for the Advancement of Teaching; (b) institutions with undergraduate enrollments of similar size; and (c) institutions with similar 4-year averages of NSF Division of Undergraduate Education (DUE) funding, which is a measure of the level of pedagogical reform activities at a given institution. Based on these criteria, we selected Institution A located on the West Coast, Institution B located in the Mountain West, and Institution C located in the Midwestern United States.

A variety of pedagogical reform initiatives were active during the time of data collection. At Institution A both the physics and biology departments had external support for faculty development and curricular reforms, and a campus-wide teaching and learning center offered workshops for students and faculty. At Institution B a major cross-disciplinary effort involving curricular reform and targeted technical assistance was active, in addition to other campus-wide and departmental efforts. At Institution C a cross-disciplinary initiative focused on doctoral education provided workshops to students and faculty, along with other efforts including a center focused on biology education. Finally, at each institution cross-disciplinary initiatives had engaged faculty from mathematics, chemistry and geology.

The sampling frame for this study included all individuals listed in the spring 2010 timetable as the instructor of record for undergraduate courses in math, physics, chemistry, biology, and geology departments across the three institutions. Our focus on these courses was driven by
the desire to examine instructional practices across the whole range of undergraduate education in these fields—including the so-called “gateway” courses, upper-level courses for majors, and lower-level courses for non-STEM majors. Thus, our sample included courses such as: General Chemistry, Organic Chemistry, General Physics, Mechanics, Calculus, Differential Equations, General Biology, Developmental Biology, Intro to Geology, among others. Given our focus on these undergraduate courses it should come as little surprise that over half of our participating instructors were non-tenure track (NTT) faculty at the time of the data collection (see Table 1). Indeed, national estimates show that over half (56.2%) of instructors across all institutions of higher education are NTT faculty, a trend that appears to be steadily increasing since 1975 (American Association of University Professors, 2009).

A team of three researchers conducted all data collection activities during the Spring semester of 2010. For the interviews, a semistructured protocol ensured that all researchers asked the same general questions, but interviewers were encouraged to explore certain themes if presented an opportunity in the moment. One researcher observed two class periods of each participant, with interviews typically taking place immedi-
ately prior to or after an observed class. During the data collection we were sensitive to the possibility that the interview and our classroom presence may influence instructors’ teaching practices. In order to minimize this influence we maintained a low profile in the classroom and made the effort to clarify that our research objectives were purely basic and exploratory rather than evaluative. While our interviews certainly prompted greater reflection about instructional practices than many of the participants typically engage in, given the candid and critical responses we recorded during the interviews we did not get the impression that our presence was considered threatening or judgmental toward their instructional practices. Finally, given the variety of pedagogical reform initiatives underway at the three sites, many of the instructors were already accustomed to having the presence of researchers or evaluators in their departments and classrooms.

For this specific analysis we focused primarily on the participants’ responses to the following two questions: (1) What is your view about how students best learn the key concepts in your field? (2) What are the most effective ways to introduce students to these key concepts? These questions were part of a longer interview with each instructor ranging between 30–60 minutes. While we focused primarily on participants’ responses to the two questions above, we also used a number of utterances from across the entire interview. The interviews were conducted in the privacy of participants’ offices and the audio recordings were later transcribed.

In addition to the interviews, each participant was observed for two full class periods using the Teaching Dimensions Observation Protocol (Hora & Ferrare, 2013), which was used to code the instructors’ use of teaching methods (e.g., lecture, small group work, demonstration), student/instructor interactions (e.g., forms of Q&A), cognitive engagements (e.g., memorization, problem solving, creating), and instructional technologies (e.g., clickers, chalkboard, slides) at 5-minute intervals throughout the duration of each observed class period. Prior to the observations, the three researchers participated in a 3-day training process. In order to test inter-rater reliability, the analysts coded three videotaped undergraduate classes (two in chemistry and one in mathematics). The following Kappa statistics were observed for each pair of raters: Analyst 1/Analyst 2 (.699), Analyst 1/Analyst 3 (.741), Analyst 2/Analyst 3 (.713).

Constructing Cultural Models of Teaching and Learning

The first phase of the analysis involved two distinct steps: (1) a thematic analysis of the interview transcripts, and (2) clustering/scaling
of the derived themes. All interviews were transcribed and entered into NVivo® qualitative analysis software. Two analysts developed an initial coding scheme in order to segment the data into thematically coherent units. In developing the initial code list, the two analysts conducted an inductive analysis of the data that entailed comparing each successive instance of the code to previous instances in order to confirm or alter the code and its definition (i.e., the constant comparative method) (Glaser & Strauss, 1967). The two codes created during this process that are salient to this article include “views of student learning” and “introducing new topics.” Prior to coding the entire sample, the analysts applied the coding scheme to five transcripts and inter-rater reliability was assessed by calculating the percentage of agreement between the analysts in applying the codes. The percentage of instances in which both analysts coded the same code relative to all coded instances was 89%.

Next, an in-depth analysis was conducted of all text fragments coded as “views of student learning” and “introducing new topics” in order to identify recurrent themes and patterns (Ryan & Bernard, 2003). This entailed an open coding and constant comparative process as detailed above. In analyzing the “introducing new topics” themes we discovered that, while many participants had the same themes, the sequence in which the themes were reported varied substantially. We therefore took a second step in our thematic analysis in order to derive the temporal sequence through which the themes were connected.

The second step involved creating a participant-by-thematic code matrix in which each cell indicates whether participant i expressed thematic code j (1) or not (0). We then used cluster analysis and multidimensional scaling to explore the dimensions underlying the relationships within and between the two sets of themes (i.e., views of learning and new topics sequences). Cluster analysis is a nonstatistical procedure for partitioning objects (i.e., themes) into groups based on (dis)similarity as measured through a distance matrix (in this case binary squared Euclidean distance). The particular clustering algorithm used in this analysis is referred to as Ward’s Method, which begins with each theme (or theme sequence) as its own cluster and ends with a single cluster that contains all the themes. In between the beginning and end are the stages of clustering that are based on the merging of clusters that result in the smallest increase in the value of the sum of squares index by the clustering (Romesburg, 1984). The primary output in cluster analysis is the dendrogram—a diagram that illustrates the clusters and decision-steps the algorithm made to attain them.

As a complement to the cluster analysis we used multidimensional scaling (MDS). Rather than partitioning the themes into mutually ex-
MDS is a technique for graphically representing the proximities (i.e., [dis]similarities) between objects (e.g., interview themes) as distances in a low dimensional space. Two advantages of using MDS as a complement to cluster analysis include the ability to assess the fit of the solution (discussed below) and to interpret the latent dimensionality of the distances. The latter advantage provides opportunities for the analyst to interpret the underlying (and unobserved) principles that explain the relative positions and distances between objects in the data space. This interpretive step is very similar to the interpretation of components in principal component analysis (Borg & Groenen, 2005).

In the present application of MDS distance is conceptualized as Euclidean distance, which is simply the geodesic between two points. In a two-dimensional solution (X) the Euclidean distance \(d\) between points \(i\) and \(j\) can be expressed as:

\[
d_{ij} = \sqrt{(x_{i1} - x_{j1})^2 + (x_{i2} - x_{j2})^2}
\]

(1)

Euclidean distance can be re-written more generally to apply to \(m\)-dimensions:

\[
d_{ij} = \left[\sum_{a=1}^{m} (x_{ia} - x_{ja})^2\right]^{1/2}
\]

(2)

An optimal MDS solution is one in which the distances closely approximate the proximities. Borg and Groenen (2005) refer to this as a representation function \(f\):

\[
f: \delta_{ij} \rightarrow d_{ij}
\]

(3)

in which \(f\) indicates the type of MDS model. There are numerous types of MDS models, but by far the most common in social science research is ordinal (or nonmetric) MDS. In ordinal MDS the proximities are treated as a rank ordering rather than an actual distance. Therefore, the distances \(d_{ij}\) are regressed on the proximities \(\delta_{ij}\) by way of a monotonic function. The resulting differences between the monotonic regression line and the nonmonotonic line are referred to as the disparities \(\hat{d}_{ij}\), which represent a smoothed version of the distances \(d_{ij}\).

In order to assess the fit between the disparities and the distances analysts typically evaluate the “stress” value, which is a nonstatistical mea-
sure of badness-of-fit. Kruskal’s Stress is most appropriate for ordinal MDS (Borg & Groenen, 2005; Kruskal & Wish, 1978):

\[
\text{Stress} = \sqrt{\frac{\sum_{i \neq j} \left( f(d_{ij}) - \hat{d}_{ij} \right)^2}{\sum_{i \neq j} d_{ij}^2}}
\]  

(4)

where \( f \) in this case refers to the monotonic function. While Kruskal and Wish (1978) construct an arbitrary range for acceptable stress between 0.00 (perfect) and 0.2 (poor), Borg and Groenen (2005) suggest that in practice researchers should factor in the ratio of dimensions (\( m \)) to objects (\( n \)) and the point at which increasing dimensionality no longer substantially improves fit.

**A Case-Analytic Approach to Analyzing Cultural Models in Action**

The second phase of the analysis focused on three instructors in order to examine individual instantiations of the cultural models of teaching and learning identified in the analysis of themes. The three cases were selected according to three criteria. First, we sought to select cases that together would exemplify the full range of our findings from the cluster and scaling analysis of interview themes. Second, the three cases each represent courses that serve a different role in the trajectory of STEM majors. For example, our first case below is of an instructor teaching an introductory biology course for majors (i.e. a “gateway” course). The second case is of an instructor teaching a midlevel mathematics course that is required of many STEM majors. The third case includes an instructor teaching an upper-division course that serves as a capstone for biology majors. Finally, each case represents an instructor that is differentially positioned within their respective departmental and disciplinary communities with respect to tenure status, research interests, and scholarly productivity. Thus, while it is not possible to statistically generalize from these three cases, the criteria used for selection are intended to provide a more in-depth look at the variety of cultural models we observed in relation to a range of positional contexts (i.e. tenure and disciplinary status) and instructional situations.

In each case the instructor’s themes were unpacked in order to examine more specific meanings associated with his or her cultural model, and to analyze the models in relation to their observed teaching practices. In addition to the narrative accounts of the observed classes, we used graphing techniques from social network analysis to represent the
co-occurrences between the different coded dimensions of practice: teaching methods, student/teacher interactions, cognitive engagements, and instructional technologies. Social network analysis represents a range of analytical and theoretical tools used to examine and interpret relations between sets of actors and/or events (Wasserman & Faust, 1994), such as simple directed and undirected graphs to more formal modeling approaches. Following Hora and Ferrare (2013), we use simple undirected graphs to explore the affiliations between instructional “events” across the different dimensions of practice.

The raw data for this analysis are in the form of two-mode (or affiliation) matrices that consist of each instructor’s 5-minute intervals as rows (mode 1) and observation codes as columns (mode 2). In each matrix a “1” denotes that the particular code was present in the observed interval, and a “0” denotes that the code was not present in that observed interval. Each two-mode matrix was transformed into a one-mode (code-by-code) valued co-occurrence matrix in which each cell corresponds to the number of intervals that observation code \(i\) is affiliated with code \(j\). Next, we used the program NetDraw (Borgatti, 2002) to graph the co-occurrences between each pair of codes for each instructor. The lines connecting the codes denote a co-occurrence (i.e., codes that were co-coded in the same interval), and the line thickness indicates the relative strength of the co-occurrence. Thus, for each instructor a network affiliation graph provides a graphical snapshot of their instructional practices and serves as a basis for linking the cultural models of teaching and learning to concrete classroom activities.

**Cultural Models of Teaching and Learning Among Math and Science Instructors**

The presentation of results follows three steps. First, we present the themes derived from the thematic analysis of the interview transcripts. Next, we illustrate the results of the cluster analysis and MDS of the themes, drawing primarily on the dendrogram and the MDS plot (shown in Figures 1 & 2, respectively, below) to describe the principles of organization underlying the “views of learning” themes and “introducing new topics” sequences constituting the cultural models. Finally, we conclude with the three case analyses.

**Thematic Analysis**

The thematic analysis yielded 15 distinct “views of learning” themes, 10 “new topics” themes, and 3 “new topics” sequences. Table 2 describes the “views of learning” themes in descending order of frequency.
by far the most prevalent theme is “practice/perseverance,” which was coded in half (53.7%, n = 22) of the interviews. This theme is predicated on the belief that students learn best through a sustained struggle to solve problems (both computational and conceptual) on their own. As one math faculty member stated, students “will not learn until they do it a thousand times.” Interestingly, several faculty described this view in physical or even violent terms, such as “banging one’s head against the table,” “mental weight lifting,” and “grinding away at it.” One-third (34.1%, n = 14) of the participants expressed the view that the classroom is not a good venue to learn the key concepts of their respective disciplines (the “outside the classroom” theme). In other words, faculty expressing this view felt that of all possible learning environments (e.g., laboratories, discussion sections, field work) the classroom format, particularly large “lecture” style classes, was the least amenable to facilitating student learning. In disciplines such as geology and biology, where research experiences in the field are a core part of advanced undergraduate and graduate training, faculty stated that students only really understand how to “do science” when they are forced
to design studies or collect and analyze data in the field (i.e. outside the classroom).

Many instructors (34.1%, n = 14) expressed the view that learning the key concepts is done through “application” involving hands-on engagement with the material. For example, a physics faculty member stated that students should take the principles of physics gleaned from their classes or readings and “apply them to real things.” Other frequently mentioned views of learning, described in more detail in Table 2, include “articulating” (31.7%, n = 13), “variability” (29.3%, n = 12), “visualizations” (26.8%, n = 11), “construction” (24.4%, n = 10), “experiential” (22.0%, n = 9), and “scaffolding” (17.1%, n = 7). Less frequently mentioned views include “clear explanations” (12.2%, n = 5), “examples” (9.8%, n = 4), “repetition” (9.8%, n = 4), “osmosis” (4.9%, n = 2), “individualized” (4.9%, n = 2), and “memorizing” (2.4%, n = 1).

Table 3 describes the “introducing new topics” themes and sequences in descending order of frequency. Every participant (n = 41) mentioned “covering,” which is simply the idea that the topic is defined in general or abstract terms (e.g., a theorem is presented or “oscillation” is defined). The next most frequently referenced views of how to best introduce students to key concepts is “scaffolding” (51.2%, n = 21, e.g., “I always try to use connections to things they already know.”) and “practicing/examples” (48.8%, n = 20). Other themes, described in Table 3, include: “assessing” (26.8%, n = 11), “motivating” (26.8%, n = 11), “illustrations” (17.1%, n = 7), “foreshadowing” (12.2%, n = 5), “outlining” (9.8%, n = 4), “announcing” (4.9%, n = 2), and “empathizing” (2.4%, n = 1).

As noted, the “introducing new topics” themes are not independent. Rather, they only make sense in relation to a specific sequence (or script) in which participants reported their views of introducing students to the key concepts in their discipline. For instance, two participants may have mentioned the same themes (say, covering, scaffolding, and practicing) but in the opposite order (covering→practicing→scaffolding vs. scaffolding→practicing→covering). Thus, a secondary thematic analysis classified the theme sequences. The three sets of sequences, shown in Table 3, include “specific→general” (43.9%, n = 18), “general→specific” (41.5%, n = 17), and “multi-sequential” (14.6%, n = 6). The key factor in determining the flow of the sequences was the location of the theme “covering” within the sequences. In the specific→general sequences the participants reported that “covering” was the final step in the sequence. That is, the process of introducing the topic consisted of a series of specific examples, foreshadowing, illustrations, and/or assessments that build up to a general
definition of the concept or theorem (i.e., covering). In contrast, the general→specific sequences were defined by beginning with the general definition of a concept or theorem (i.e., covering) before moving on to specific examples, assessments, illustrations, scaffolding, and so on. Finally, those participants classified as “multisequential” reported using both sequence forms depending on the topic and/or students involved.

**Clustering and Scaling of Themes and Sequences**

The next step of our analysis involved examining the patterning of these first-person accounts of student learning and teaching practice across all instructors. We began with an exploratory cluster analysis of the themes and sequences. The dendrogram in Figure 1 suggests two or three meaningful clusters related to participants’ views of how students best learn key concepts and the best ways to introduce students to these concepts. In the two-cluster stage of the analysis the first cluster comprises two subgroupings: 1A. specific→general sequences and scaffold-
The second cluster comprises general→specific sequences and the application, outside the classroom, and practice/perseverance themes.

While the dendrogram suggests a pattering into two or three clusters, it would be a mistake to interpret these clusters as neatly bound types of cultural models of teaching and learning. This caveat becomes clearer when we examine the results of the MDS analysis. Although the horizontal distances between the themes and sequences in Figure 2 follow an ordering consistent with the cluster analysis, the distances do not suggest two or three discrete groupings. Instead, the horizontal dimension of the MDS space illustrates an opposition between the themes in subgroup “A” (from cluster 1) and cluster 2, with the themes in subgroup “B” being more similar (i.e., closer) to the former than the latter. The principle underlying this opposition approximately follows a dis-

![Dendrogram](image)
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...tinction between learning as a result of teaching (e.g., scaffolding, osmosis, clear explanations, visualizations, etc.) versus learning that is the result of doing (e.g., application, outside the classroom, and practice). While this finding does not discredit a two-cluster model, it does suggest a greater deal of variation in the way these instructors assemble the themes within cluster 1.

While the horizontal distribution of themes in Figure 2 approximately replicates the pattern of clustering, the results are more nuanced when we integrate the second dimension of the MDS space. With the notable exception of the practice/perseverance theme, this vertical dimension contrasts teacher-constructed views of knowledge construction and learning to that of student-constructed views. The teacher-constructed views include themes that emphasize techniques and strategies that the instructor must do to construct knowledge, such as providing visualizations, scaffolding, and examples. In contrast, the student-constructed views include themes suggesting that students must articulate, construct, and apply—particularly outside the classroom. Coinciding with the initial clusters, then, is an additional principle pointing to contrasting views related to who is responsible for the construction of...
knowledge in the pedagogic relationship. Thus, the MDS results add a dimension to the cultural models of teaching and learning presented thus far.

Practically speaking, rather than thinking of these cultural models as discrete types, it is more accurate to conceptualize them as spatially proximal combinations of learning views and new topic sequences that are organized across multiple principles of differentiation. That is, in practice, the boundaries between these cultural models appear to be separated less by rigid “either/or” categories and more by “to what degree” distances. This premise will prove even more convincing once we move from examining cultural models on paper (i.e., as theoretical constructs in Euclidean space) to an analysis of cultural models in practice.

Case Analyses

While the case analyses below reinforce the theoretical boundaries of the cultural models identified heretofore, they also portray a degree of fluidity with which each instructor constructs meanings and practices in relation to their cultural model of teaching and learning in specific instructional situations.

“Dr. Spicoli.” Dr. Spicoli is a professor of biology who teaches a large (~350 students) introductory-level course in genetics that is required of all biology majors. The two class periods we observed covered gene identification, gene sequencing techniques, embryonic testing, and technologies for measuring DNA. Dr. Spicoli’s cultural model of teaching and learning falls primarily in cluster 2, or the “learning by doing” region of the MDS space. This can be seen in his theory that the way students best learn the key principles of genetics is through practice that happens outside the classroom, and his general→specific sequence script (covering→motivating→scaffolding) as the best way to introduce students to these concepts.

Dr. Spicoli does not hesitate when asked about what he thinks is the best way for undergraduate students to learn the key concepts of genetics: “Problem solving,” he replies assuredly. “[T]o get them proficient in solving genetic problems and understanding concepts,” he continues, “is just to do problem solving.” It is not surprising, then, that Dr. Spicoli holds that learning primarily occurs outside the classroom where students can engage in problem solving specific to genetics. To this end, Dr. Spicoli assigns weekly problem sets and makes graduate students and proficient undergraduates available for 1 hour per week so that students can ask questions and get feedback on their work.

While Dr. Spicoli’s model locates student learning in problem-solving contexts outside of the classroom, he nonetheless is tasked with
introducing students to the principles of genetics inside the classroom. When introducing students to new material Dr. Spicoli believes it best to begin by defining the key terms and providing an overall definition of the concept(s). This initial step of covering and outlining is followed by motivating and scaffolding the new material so that, in his words, “it’s not just me filling 50 minutes with some technical stuff that they may or may not be interested in, but try to tell them how it’s relevant and how it’s connected to other parts of the course.” Yet Dr. Spicoli’s rationale also links back to his model of student learning based on practice through problem solving. As he notes, “[I] try and give them the flow of how a geneticist goes through trying to figure out when they have a new mutation or a new phenotype.” Thus, Dr. Spicoli’s theory of how students best learn key concepts in genetics operates in association with a script for introducing students to those concepts.

By observing Dr. Spicoli’s instructional practices we can begin to understand how his cultural model of teaching and learning is enabled and adapted to the specific context of his instructional environment. The network-affiliation graph in Figure 3 illustrates that Dr. Spicoli’s primary pedagogical repertoire consists of a didactic style that requires students to frequently receive, follow, and memorize information presented through lecturing with the use of a pointer and PowerPoint slides. In some ways Dr. Spicoli’s practice appears to contradict his cultural model. However, he does frequently supplement his didactic style by asking students to solve conceptual genetics problems through the medium of clicker response systems (i.e., real-time polling). These questions are often situated within a specific genetics case study (e.g., homologous genes and gene sequencing).

Although Dr. Spicoli’s cultural model of teaching and learning is clearly at work in his instructional practice, the application of the model is not purely deterministic. Rather, his cultural model is recontextualized by the constraints and affordances of his instructional environment. Most notably, the high enrollment numbers and varying levels of student ability shape the extent to which he can incorporate problem solving into the classroom. This is particularly evident with the use of clickers. As he notes, “With the size of the class and very different skill levels among the entering students here in biology, I don’t do a lot more sophisticated clicker stuff that some of my colleagues do.” Even though Dr. Spicoli’s cultural model of teaching and learning represents a relatively coherent theory that he uses to make sense of his instructional environment, this same environment pushes back in a way that requires him to adapt his cultural model (or at least make concessions) to the constraints he perceives in the situation. Even in the face of those con-
straints, however, instructional technologies such as clickers afford Dr. Spicoli a medium through which to act upon certain features of his cultural model.

"Dr. Denny." Dr. Denny is a senior instructor in the mathematics department. At the time of the interview and observation, Dr. Denny was teaching a linear algebra course (~40 students). The week we visited Dr. Denny’s class he was covering basic principles in matrix algebra and more complex concepts related to vector spaces. Dr. Denny espouses a cultural model of teaching and learning that is primarily comprised of themes from subgroup A of cluster 1 (i.e., “learning through teaching”) and the teacher constructed region of the MDS space. For instance, in addition to “practice,” his theory of how students best learn key mathematical concepts is characterized by variability, working through examples, and integrating concepts through scaffolding. Dr. Denny also has a specific→general script for introducing students to key mathematical
concepts that begins with numerous examples and gradually builds to a
general principle or theorem.

When prompted to think about his views of how students best learn
the key concepts in linear algebra, Dr. Denny notes that linear algebra
marks a transition from strictly doing computations to more abstract
forms of mathematical reasoning. In this context he perceives students
to learn at different speeds and through varying styles and thus stresses
variability. Regardless of speed or style, though, Dr. Denny contends
that in order for students to learn key mathematical concepts they
must “grind away” through numerous specific examples and gradually
work up to the general principle or theorem. He also holds that stu-
dents must have a strong foundation (i.e., scaffolding) in the fundamen-
tals of mathematics before they can grasp more advanced and abstract
concepts.

Associated with Dr. Denny’s theory of how students best learn key
concepts in linear algebra is a script for introducing students to those
concepts. This script runs counter to what he describes as the “common
model” (i.e., general→specific) in mathematics:

I know a lot of people who come in and will state the theorem . . . and prove
it and then finally do some examples, and I never do that. I do an example,
and then I’ll do another example, and as I do them I’ll point out some feature
and I’ll say, “Well, we call this thing . . . Gauss-Jordan elimination. . . .” I do
a bunch of examples and then try to lead into the abstract definition.

When asked to say more about the common model (i.e., proving the
theorem and then providing examples), Dr. Denny says that most math-
ematicians teach that way because “[t]hat’s the way they’re comfortable
thinking.” He continues:

But it doesn’t seem like the most natural way to learn to me personally. I
think you understand it abstractly. [W]hen you learn algebra, that’s very ab-
stract. You learn arithmetic—even numbers are abstract, right? . . . But even-
tually you learn that numbers are something and then in algebra you have to
say let X be a number. So you have this variable, which is an abstraction of a
number, and a number is an abstraction of something else . . . but you don’t
learn algebra until you’ve really learned arithmetic . . . Because then you
have a bunch of examples of computations that you can imagine you would
want to write in this language—and it keeps going like that. [Y]ou always
work from the particular to the general.

The latter quote captures the essence of Dr. Denny’s cultural model
of teaching and learning, as it illustrates his views that students must
work through specific examples and build scaffolds as they proceed to higher levels of abstraction. Thus, the way Dr. Denny believes new topics should be introduced is a microcosm of his broader model of progression in mathematics.

In the classroom it was easy to see Dr. Denny’s cultural model of teaching and learning in action. During each class period he meticulously worked through examples, beginning with easy applications and gradually working up to more difficult problems that prompted student questions. This core pedagogical style is evident in Figure 4, which shows that Dr. Denny frequently lectures while working through problems at the chalkboard. The graph also demonstrates that Dr. Denny supplements his primary strategy of working through problems by occasionally posing algorithmic and conceptual questions to the students, and he frequently checks for student understanding. What the graph does not illustrate, however, is that as Dr. Denny progressed through each problem he would periodically stop and point out certain features of the problems that eventually could be assembled into an abstract principle.

For Dr. Denny, the use of the chalkboard provides a medium through which he is able to act upon his cultural model of teaching and learning. Since he prefers to provide students with many examples, Dr. Denny’s modus operandi is to stand at the board and work out problems. Although the component of Dr. Denny’s cultural model related to introducing key mathematical concepts runs counter to what he claims is “the more common model,” he is certainly not alone in relying on the chalkboard as an instructional tool. When asked to clarify his use of instructional technology, Dr. Denny notes that while he does believe the students should be using the computer program MATLAB—a programming environment for algorithm development, data analysis, visualization, and computation—he is conflicted about the use of such technology:

And there is a move to [use MATLAB], but mathematicians are kind of conservative. I’m kind of conservative. We sort of like our discipline to be sort of pure in some sense and so what we really want [students] to see is the beauty of these ideas, and of course . . . kicking and screaming we admit that these things are actually useful for something, and . . . we’ll teach you how to do it. . . . But really we want you to be stunned by the loveliness of it.

This sentiment illustrates the conflicting components of Dr. Denny’s cultural model. On the one hand, his model guides him to sequence the material in contrasting style to the more common model in mathematics.
On the other hand, he is intent on accommodating the conflicting positions within his model by using the chalkboard to work through examples as opposed to a technological medium that he admits the students “should learn.”

“Dr. Bishop.” As a senior instructor in biology, Dr. Bishop is primarily responsible for teaching undergraduate courses covering a variety of biological concepts. In addition to her teaching commitments, Dr. Bishop is involved in undergraduate science education research projects that have provided her with data to inform her teaching. In this sense her cultural model of teaching and learning extends beyond a folk theory and includes features of a scientific theory. The particular course that was observed in the present case was Developmental Biology, which is an upper division course for biology majors in the department (~100 students). Dr. Bishop’s cultural model of teaching and learning cannot easily be characterized. It is considerably more nuanced than the previ-

**Figure 4.** Dr. Denny’s graph of instructional practice.

*Note.* The black boxes refer to teaching methods and interactions, white boxes refer to cognitive engagements, and gray boxes refer to instructional technologies.
ous two cases, and it contains themes from across the entire spectrum of cultural models analyzed thus far. In total, Dr. Bishop expressed seven distinct thematic views of student learning—variability, construction, articulating, outside the classroom, osmosis, individualized, and application—and espouses multiple scripts for introducing students to the course material.

The complexity of Dr. Bishop’s model is captured in her initial response to being queried about the best way students learn key concepts in developmental biology. “I guess there [are] two answers to that question,” she replies. The first answer, according to her, is that “different people learn the key concepts differently” and that “students have a clear preference for [certain] learning styles.” Some students, she claims, are most comfortable coming to class, taking notes, and then going on their own to piece together the key bits of information rather than actively pursuing that knowledge in the classroom. For Dr. Bishop, independent study, reflection, and application outside of the classroom are “critical components” to learning the key concepts.

Despite her belief in variability and acknowledging that some students are not comfortable in an active learning environment, Dr. Bishop’s second answer is more definitive in the other direction. “So I guess . . . there’s a student perspective” she says, “but from my own perspective I think that students learn by being active.” Dr. Bishop continues:

I think that a lot more is gained from—and there’s data to support this too—but there’s a lot more to be gained from an active pursuit of the topic in the classroom. Where the things that are confusing you, [you can] actually hash it out when you’ve got the professor there to talk with you about it and you’ve got your neighbor to go, “Well, I don’t think that’s the way it works.”

Being active, according to Dr. Bishop, thus involves a combination of construction (“active pursuit of the topic in the classroom”), articulation (“hash it out”), and individualized interaction between the instructor and each student. In the process of explaining her cultural model, Dr. Bishop notes that “there is data to support” her model. Here we can see that Dr. Bishop’s cultural model of teaching and learning is more explicitly theoretical than what is typical among many of the scientists and mathematicians we interviewed.

The complexity of Dr. Bishop’s cultural model is also captured by her views of how to introduce undergraduate students to the key concepts in biology. Dr. Bishop espouses both a general→specific (covering→examples) and specific→general (assessing→covering) script for introducing material. When asked if there is a pattern to her
use of the former or latter sequence, she has to think about it for a few seconds:

I’m trying to think about whether there is a method to my approach. . . . I guess, all right just being honest, I think I would prefer . . . to start every class period or every topic with an exploration on their part, culminating with some wrap-up by me. But in practice there are some number of topics that I don’t start that way, and it’s just because I haven’t developed the right sequence of things that I think will trigger them to really learn it that way.

Similar to her views of student learning, Dr. Bishop’s views of how to introduce key concepts must be understood in relation to her interactions with students. That is, she clearly prefers active over inactive learning and specific→general over general→specific sequences. Yet, rather than expunging these elements from her cultural model, Dr. Bishop has instead adapted them to fit (albeit in conflict) alongside what she believes is the best way to teach and learn.

![Figure 5. Dr. Bishop’s graph of instructional practice.](image)

*Note.* The black boxes refer to teaching methods and interactions, white boxes refer to cognitive engagements, and gray boxes refer to instructional technologies.
Given the complexity of Dr. Bishop’s cultural model of teaching and learning, it should come as no surprise that her pedagogical style is highly varied. Indeed, the total number of unique nodes (i.e., observation codes) in Dr. Bishop’s graph \((n = 21)\) is nearly double that of Drs. Spicoli \((n = 11)\) and Denny \((n = 12)\). In addition, a core/periphery relation of techniques is not as distinct as in the previous graphs; Dr. Bishop’s graph is more diffuse. It is in this graph that we can see a multifaceted configuration of educational action that is approximately homologous to her multifaceted cultural model of teaching and learning. For instance, note that lecturing from a laptop and slides is still a key feature of the graph. During these times both sequences of introducing material were at work. Often when lecturing, for example, Dr. Bishop was introducing a principle or process (e.g., axonal movement) followed by a series of examples. At other times she would instead share very specific pieces of data and ask the students, “What is happening here?”

While lecturing with a laptop and slides is an important feature of the graph, the prevalence of active instructional practices and technologies illustrates the varied aspects of Dr. Bishop’s cultural model in action. For example, Dr. Bishop makes regular use of conceptual clicker questions, brainstorm sessions, small group discussions, individual deskwork, and a variety of question styles. In the process she creates the conditions for a number of active cognitive engagements such as creating, connections, problem solving, and integration. Finally, all of this is accomplished through a mixture of instructional technology that includes an overhead projector, laptop and slides, digital tablet, and clicker-response system.

**Discussion and Conclusions: What Can We Learn From Cultural Models of Teaching and Learning?**

At the outset of this article we claimed that cultural models are an important theoretical tool that can help us to better understand postsecondary instructional practices and attempts to reform them. Our primary theoretical argument was that cultural models of teaching and learning should be explored at the intersections of instructor cognition, teaching practices, and instructional environments. We began this process by examining the first dimension (i.e. cognition) in relation to instructors’ expressive/conceptual models of how students best learn foundational concepts and their scripts for introducing students to this material. The clustering and MDS analyses point to two (or possibly three) broad
forms of cultural models for these practices that are primarily organized by two underlying principles. These principles differentiate the participating math and science instructors’ views of who constructs knowledge in the pedagogic relationship and how such knowledge is learned or acquired. Thus, while very few of the participating instructors formally study pedagogy, it is notable that their expressive/conceptual models and scripts are organized into relatively coherent theoretical constructs.

In fact, it was Dr. Bishop—the most sophisticated, articulate, and theoretically astute pedagogue among our participants—who had the most theoretically diverse and contradictory cultural model. We conjecture here that instructors who intentionally seek to transform their models of teaching and learning do not fully expunge their initial model. Instead, they add new meanings and strategies and adapt them to fit alongside components of their preexisting models—even when the new meanings exist in conflict with the preexisting. In the case of Dr. Bishop, these conflicts exist out in the open and represent a source of tension in her practice. Thus, an important question for future research is: What are the consequences of conflicting models for the ways instructors teach and, subsequently, how these practices impact students’ learning experiences in classroom settings? At first thought it may seem that having multiple, conflicting models can have contradictory consequences in the classroom. On the other hand, having multiple models allows for greater reflection and critique (Gee, 2005) and may assist instructors in adapting to a greater range of instructional situations.

The results above also suggest that cultural models of teaching and learning among math and science faculty are differentially distributed within and between groups. While we did not formally explore the precise social contexts of this distribution, some anecdotal references from the transcripts indicate that disciplinary and status positions may be a productive starting point for future examination. For example, both Dr. Denny and Dr. Bishop—as non-tenure track senior instructors—referenced their positions within the academic hierarchy as affording them opportunities to reflect on student learning and pedagogical strategies. Dr. Spicoli—as a tenured professor—also recognized that the disciplinary and institutional reward system unevenly motivates teaching innovation. In addition, Dr. Denny’s statement about the “common model” of introducing a theorem in mathematics points to discipline-specific components to the cultural models. These statements lead us to posit that instructors perceive constraints and affordances in their disciplinary and organizational status positions (cf. Martin, 2011). Future work should look deeper into these sociological facets of cultural models and
further develop the theoretical links between social and cognitive structures in these settings.

While our three cases illustrate the generative properties of instructors’ cultural models of teaching and learning with respect to their classroom practices, they also point to the danger in viewing these models as directly corresponding to those practices. Indeed, as we saw above, it is at the intersections of instructors’ practices and the constraints and affordances that they perceive within their instructional settings where we come to understand how these cultural models are enabled and constrained. This may partially explain why, at times, the instructors used teaching practices that embodied components from cultural models other than those they espoused. Thus, while there can be little doubt that instructors’ cultural models of teaching and learning motivate practice, we must also recognize the powerful ways in which instructional situations and environments (e.g., class size, access to instructional technology) interact with these models to ultimately shape practices. This relational view suggests that the transformation of cultural models of teaching and learning necessarily involves a transformation of the environment and the ways in which those environments are perceived as affording or constraining certain actions. Indeed, it is hard to imagine the evolution of these cultural models occurring without the coevolution of the environments in which they are constructed and enacted.

It is not only the instructional environment that shapes how instructors translate their cultural models into instructional practice. Another important intersection is in relation to actually existing instructional practices. That is, the extent to which instructors are able to translate their models into practice is dependent upon the availability of an existing form of practice that embodies the principle underlying its use. For example, recall that one of Dr. Bishop’s scripts for introducing students to new topics is constrained by the lack of an existing practice to match her model. As she notes, “But in practice there are some number of topics that I don’t start that way [specific—general sequence], and it’s just because I haven’t developed the right sequence of things that I think will trigger them to really learn it that way.” A similar process was observed with Dr. Spicoli, who had yet to find a way to implement some of the more sophisticated problem solving techniques using clickers in his large lecture hall setting. In this instance we see his cultural model constrained by multiple intersections—the instructional setting and the lack of available (or known) practices to match his model.

Our analysis of math and science instructors’ cultural models of teaching and learning also point to a number of implications for those involved in the ongoing efforts to transform undergraduate STEM
education. A commonly referenced step toward transforming the educational experiences of undergraduates in these fields is to change the culture of instruction (Kezar & Eckel, 2002; Trowler, 2008; Wieman et al., 2010). Although the definition of culture can vary widely across researchers and reformers (if it is defined at all), proponents of this view generally argue that it is necessary to change instructors’ preexisting understanding(s) of how students best learn and the strategies that create the conditions for this learning to flourish. In other words, proponents of this view are making an argument for changing the cultural models of teaching and learning within math and science disciplines.

However, the momentum of evidence points to a Sisyphus scenario in which reformers have invested impressive efforts and resources without widespread change (President’s Council of Advisors on Science and Technology, 2012). Our findings suggest that the downfall of this strategy is in the failure to recognize and appeal to the practical logic of instructors’ preexisting cultural models. Preexisting cultural understandings are persuasive by definition (Gramsci, 1971; Quinn & Holland, 1987), and this is no less true for math and science instructors’ cultural models of teaching and learning. Rather than perceiving instructors’ preexisting understandings as the sole objects of change, therefore, it may be more productive to recognize those understandings as also containing elements of “good sense” (to use Gramsci’s phrase) upon which to build (cf. Spillane, Reiser, & Reimer, 2002). That is, just as some instructors perceive affordances in instructional tools to overcome practical constraints, practitioners and policymakers can perceive affordances in instructors’ cultural models to motivate pedagogical innovation. In this sense the “culture of instruction” represents an opportunity to initiate meaningful transformation in the educational experiences of students and educators (see also Trowler, 2008).

At the same time, our theoretical perspective focusing on the intersections of cultural models, teaching practices, and instructional environments indicates that transforming instructors’ cultural models of teaching and learning is an incomplete goal. As we saw above, instructors often perceive a variety of constraints (e.g., class sizes, students’ own cultural models of teaching and learning, and technological resources) that are associated with pedagogical strategies and actions that, in effect, constitute concessions and adaptations to their model that they would not otherwise make. This suggests that the burden of responsibility for meaningful transformation is not solely that of instructors, but is distributed throughout the actors, events, and environments that constitute educational activities. An instructor-centric approach to pedagogical transformation evades the complexity and relational nature
of education. A more complete approach must account for the features of instructional environments and situations, social structural positions (e.g., tenure systems), and students’ own cultural models of teaching and learning. These additional intersections may point to educational opportunities that have yet to be pursued.

Notes

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References


