

# Navigating the Problem Space of Academia: Exploring Processes of Course Design and Classroom Teaching in Postsecondary Settings

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# **Navigating the Problem Space of Academia: Exploring Processes of Course Design and Classroom Teaching in Postsecondary Settings**

**Matthew T. Hora**

Postsecondary institutions in the United States are under increasing public and political pressure to demonstrate their delivery of a high-quality educational experience that leads to demonstrable outcomes including student learning and employability in the labor market (Arum & Roksa, 2011; Bok, 2006). Many critiques of higher education and current policy initiatives center on the instrumental role of classroom teaching, and how the widespread adoption of techniques grounded in the learning sciences could lead to such positive outcomes (e.g., President’s Council of Advisors on Science and Technology, 2012). As a result, a growing area of interest in both research and policymaking circles is whether faculty<sup>1</sup> effectively incorporate techniques such as problem-based learning (Hmelo-Silver, 2004) or Peer Instruction (Mazur, 1997) into their teaching, and, if not, what contributes to the rejection of these techniques.

However, most analytic attention is on what happens in the classroom and not the planning processes that take place long before a class begins. This is problematic because improved teaching and student learning is as dependent upon faculty developing a pedagogically informed and deliberate approach to curriculum planning as it is to sound classroom practice. Indeed, instructional reforms such as the scientific teaching approach (Handelsman et al., 2004) encourage faculty to use formative and summative assessment data in an ongoing, iterative approach to planning and teaching their courses. Yet, as Joan Stark observed, “most attempts to improve teaching and learning in colleges have focused on the teacher’s role as a ‘classroom actor’ rather than as an ‘academic planner’” (Stark, 2000, p. 413). Thus, understanding the dynamics underlying faculty decisions about whether or not to adopt instructional innovations requires an expansive view of faculty practice that encompasses their roles as academic planners, not merely classroom actors.

Furthermore, course planning and classroom teaching practices should be situated within their unique disciplinary and professional contexts. The ways in which the task environment influences how teachers approach classroom instruction (Shavelson & Stern, 1981; Schoenfeld, 2000), curriculum design (Remillard, 2005), and policy implementation (Coburn, 2001) has long been an active and influential area of research in K–12 settings. Notably, these lines of inquiry are deeply influenced by theory and method from cognitive psychology and the learning sciences, especially in exploring the subtle dynamics whereby individuals perceive and interpret

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<sup>1</sup> By faculty I mean all people who hold undergraduate teaching positions—whether full- or part-time, tenured or untenured—in postsecondary institutions with the exception of graduate teaching assistants. As such, an examination of the effects of different postsecondary appointments on pedagogical beliefs and/or instructional decision making is beyond the purview of this paper. For more details regarding the sample, see pp. 7ff.

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their situations in ways that shape their decisions and actions (Greeno, 1998). The interactions between individuals' attributes and their environments as they make decisions are a critical feature of educational practice, and thus a potentially important leverage point for facilitating or affecting change (Spillane, Reiser, & Reimer, 2002).

In contrast, the literature exploring how postsecondary faculty plan and teach their courses tends to adopt a “black box” approach to the relationships among context, decision making, and practice. For example, a common way to conceptualize the influence of contextual factors on teaching is captured by a model used by Umbach (2007), which posits that “Faculty subcultures (professional, institutional, and disciplinary)→faculty teaching→student learning” (p. 266). Besides assuming a linearity of cause-effect relations that may not in fact exist, such an approach leaves the specific and subtle dynamics between situations and teaching behaviors unexamined. Promising lines of inquiry shed light on these interactions in colleges and universities, including examinations of how pedagogical beliefs and goals are “filtered” by the local context (Stark, 2000), how faculty interpret and navigate their institutional and sociocultural environments (e.g., Trowler & Knight, 2000), and how “situational factors” such as class size are perceived by faculty as constraining or affording the adoption of pedagogical innovations (Henderson & Dancy, 2007).

Yet, little empirical research has been conducted on the specific processes whereby faculty decisions about teaching are influenced by their environments, particularly from a practice-based perspective. Indeed, educational researchers across the K–16 spectrum have advocated for more practice-based research on teaching, so that *how* and *why* educators make decisions in “the wild” of classrooms and school hallways is better understood (e.g., Bastedo, 2012; Halverson & Clifford, 2006). In this paper, I report findings from an exploratory study that focused on the instructional decisions made by a group of 58 postsecondary math and science faculty while planning their classes in three public research universities. At the heart of this investigation is the notion of a “problem space,” which is an idea from cognitive science that refers to how a task is perceived by the problem solver, and how subsequent goals and strategies flow from this initial construction of the situation (Newell & Simon, 1972).

Using data from a freelist exercise, retrospective recall interviews, and in-person observations of classroom teaching, I use the problem space framework to address the following questions: (1) What factors do faculty perceive as most salient to their course planning activities? (2) What specific strategies do faculty use when planning a specific course? (3) Which curricular artifacts, if any, are developed by faculty and how do they plan to enact them in the classroom? (4) How do these processes of course planning unfold in concrete instances?

Answers to these questions promise to contribute to the literature on instructional decision making in both theoretical and practical ways. By rejecting the notion that a single variable, or “magic bullet,” can explain how and why faculty teach the way they do, this study brings theory and method from the cognitive and learning sciences to bear upon the important problem of delineating the combination of factors that collectively shape how faculty view their

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work in real-world situations. Insights into these critical aspects of instructional decision making, which previously have remained an unexamined empirical problem, not only promise to contribute to the field of postsecondary education's understanding of faculty work and the dynamics of educational reform in postsecondary institutions (Spillane, Reimer, & Reiser, 2002), but also may have practical applications. In particular, evidence regarding faculty decision-making can be used to illuminate "leverage points" or organizational factors that educational leaders could support or otherwise alter in order to create the conditions for improved teaching and learning (Schoenfeld, 2000; Spillane, Halverson, & Diamond, 2002).

### **Background**

Extensive bodies of research have explored the dynamics among instructional decision making, organizational contexts, and teaching practice in both higher education and K–12 schools. Because a survey of these various literatures is not within the purview of this paper, in this section I provide a brief overview of the key literatures that have informed and inspired the present investigation. These include research on curriculum design in both postsecondary institutions and K–12 settings, with a focus on studies of decision making in the classroom from a cognitive perspective. I then discuss how problem space theory, as well as conceptual tools from other theoretical traditions including situated cognition, can be used to interrogate the under-studied phenomenon of how faculty plan and then teach their courses.

### **Postsecondary Research on Curriculum Design**

Much of the early work on course planning and curriculum design in higher education was largely conceptual, and, instead of examining how faculty went about designing their courses and programs, researchers sought to develop explanatory models of planning largely to aid designers in developing and improving degree programs (Conrad & Pratt, 1983; Dressel, 1980; Mayhew & Ford, 1971). These efforts entailed complex models that included numerous boxes and arrows denoting causal relations among factors. For example, Dressel's (1980) model posited six continua upon which programs can be characterized (e.g., continuity to fragmentation) that administrators and curriculum designers should consider as they designed new programs. However, Conrad and Pratt (1983) critiqued this approach to modeling curricular design for ignoring the constituent parts of the planning process and the myriad contextual influences that shape them, as well as being an overly linear accounting of curriculum development that likely did not reflect how curricula were designed in real-world settings. Instead, their model comprises a recursive and non-linear process whereby a wide range of factors shape how curricular decision making unfolds, including environmental inputs (e.g., professions, community), the nature of the material, instructional traditions, and resource allocations, to name but a few (Conrad & Pratt, 1983).

This shift from abstract models of curriculum design to more grounded, descriptive accounts of how faculty designed their courses in practice was the hallmark of the research program of Joan Stark (Stark & Lowther, 1986). Motivated in part by advances in cognitive science, Stark and colleagues sought to identify precisely how deliberate faculty were in

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designing their courses. Given the autonomy that many postsecondary faculty enjoy in planning their courses, Stark hypothesized that personal characteristics such as beliefs about teaching and learning, and experiences as an instructor, would largely drive their decisions about the structure and content of a course. However, these individual-level factors did not unilaterally dictate faculty behaviors, as they were influenced or “filtered” by features of the organizational context that ultimately determined how a course was designed and taught (Stark, 2000). A key finding from this research program was that much of postsecondary instructors’ planning for a previously offered course (versus planning for an entirely new offering) involves minor alterations to existing materials on account of the fact that instructors often teach the same course(s) year to year—what Stark (2000, p. 420) called “routine maintenance.”

This body of evidence remains the most extensive and comprehensive work on faculty course planning to date, but, given changes in the nature of higher education and faculty teaching in the intervening 25 years, the field would benefit from more recent empirical work on these topics (see Lattuca & Stark, 2011 for a more prescriptive approach to curriculum design). Additionally, this work was primarily survey based and thus did not capture or describe the subtle features of faculty decision making as it unfolded in real-world situations. The importance of such descriptive work was noted by Stark (2000, p. 435) who stated, “Our work fell short of exploring in depth the actual decisions teachers make about course plans and curriculum.”

While the notion of contextual filters suggests a theoretical grounding in work on perception and situated cognition, it was not until scholars in the United Kingdom and Australia began to investigate the nature of faculty thinking that research on instructional decision making took a decidedly cognitive turn. Much of this work focused on identifying particular conceptions or approaches to teaching that, in turn, were theorized to shape an instructor’s classroom practice (see Hativa & Goodyear, 2001 for a review). A particularly promising line of inquiry that explicitly draws on theory from cognitive science to examine these processes is that of McAlpine and colleagues (2006), who employed the problem space construct to examine how faculty develop internal mental models of their social and organizational environment. Of particular salience to the current policy environment focused on instructional reform is an analysis of how physics faculty perceived the “situational factors” that either impeded or supported their adoption of more interactive techniques, which found student attitudes towards school, organizational expectations of content, and the lack of instruction-oriented time to be influential (Henderson & Dancy, 2007). It is this line of inquiry that the current paper builds upon by developing a more theoretically robust framework for studying curriculum design and classroom teaching, one that is strongly influenced by the extensive research on teacher decision making in K–12 schools.

### **Research on Curriculum Design and Enactment in K–12 Settings**

The focus on teacher thinking as an object of research was largely motivated by the view that, as Fullan stated, “educational change depends on what teachers do and think—it’s as simple and as complex as that” (2001, p. 115). A core idea that motivated early research on teacher cognition is that teachers are complex decision makers whose problem-solving capabilities are shaped by characteristics (and constraints) of human cognition as well as features of the

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instructional situation (Lee & Porter, 1990). In terms of curriculum design, researchers have pointed out that teachers' adapt materials to fit their strengths and views as instructors, as well as the unique needs of their students and constraints of their classrooms (Shavelson & Stern, 1981). As a result, not a single "curriculum" designed by educational experts is directly implemented in the classroom; instead there exist three instantiations of the curriculum based on teachers adapting materials to fit their own views and situations: the formal curriculum, the planned curriculum, and the curriculum actually enacted (Gehrkey, Knapp, & Sirotnik, 1992). This view represented a departure for the field, which had previously conceptualized the curriculum as a "fixed" text that was directly followed (or not) in the classroom with more or less fidelity (Remillard, 2005).

These distinctions were crucial for the field because they highlighted the active role teachers take in interpreting curricular materials to their classroom applications. This focus on interpretation and the central role of perception in shaping behavior has also been used to study policy implementation and education reform, where the processes whereby teachers interpret, adapt, or reject innovations are the primary consideration (e.g., McLaughlin, 1987; Spillane, Reiser & Reimer, 2002). According to this view, the analytic focus should be on the teacher as he or she interprets and makes sense of the curricular text rather than on the formal curriculum and the teacher's varying degree of fidelity to it.

For example, Otte (1986) crucially distinguished between the curricular artifact as an "objective scheme" (i.e., the physical form of a text) and the "subjective scheme" of how these texts are perceived, interpreted, and integrated into a teacher's practice. Remillard (2005, p. 255) adopted the view that teachers have a "participatory relationship" with the curriculum. But it is important to recognize that teachers do not interact with these texts in isolation, but instead they encounter them in specific cultural and organizational contexts "that assign to the curriculum a particular meaning" (Remillard, 2005, p. 234). This is evident in part through the curricular artifact itself, which represents an important instantiation of cultural norms and beliefs for a group (i.e., school district, discipline, institution), such that the materials may act as cultural tools that mediate as well as constrain instructional behavior in subtle ways (Brown, 2002). While research in this area foregrounds the critical role of perception in course design and classroom teaching, the processes whereby teachers' subjective schemes are generated in specific settings and then influence practice are less well examined.

### **Focus on Perception in Context: Problem Space Theory**

Thus, a critical problem facing the field is how to conceptualize the interactions between faculty perceptions of their contexts and subsequent decisions about curriculum design and classroom teaching. Research on problem solving from a situated cognition perspective provides robust conceptual tools to extend our understanding of these dynamics. A fundamental idea in teacher cognition research is that the rational choice model, which posited that humans solely make logical decisions based on a deliberate search for the best alternative among all possible choices, is not sufficient to explain how educators make decisions in practice (Lee & Porter, 1990). Instead, in addition to some element of conscious deliberation, human decision making is

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viewed as limited by certain principles of cognition (e.g., perception, memory capacity, limitations in information processing). As a result, this process of deliberation operates on both a conscious and subconscious level, and is largely shaped by the individual's unique characteristics and the nature of the situation (Greeno, 1998). An important component of this perspective is that decision makers construct a simplified mental model, or cognitive representation, of the task. This model is known in cognitive science as a "problem space" and is shaped by the individual's perception of the nature of the task, its goals, and the strategies that can best lead to the successful performance of the task (Newell & Simon, 1972). Constructing this simplified model of the task allows the problem-solver to manage the overwhelming perceptual inputs of the environment into a representation that is cognitively efficient (Lee & Porter, 1990).

Because problem spaces can be large and complex, Newell and Simon (1972) theorized that rule-like operators that link perceptions of the task with specific strategies would be used as cognitive shortcuts or "heuristics" that are reinforced over time through their successful use in solving particular problems, and thus allow individuals to minimize cognitive load in real-world tasks (Goldstein & Gigerenzer, 2002). One type of heuristic, called a "perceived affordance," refers to the relationship between perception and potential activities within a given environment. The notion of affordances was a key aspect of ecological perception theory, which focused on how the perception of particular objects involved both the reception of visual information as well as the instantaneous interpretation of the actionable properties of these objects (Gibson, 1979). For example, an individual surveying a room may visually perceive a chair and certain properties related to how she could interact with it (e.g., sitting). Later researchers focused less on the entire range of potential actionable properties of objects and instead on those behaviors that individuals perceive as possible and desirable in a given situation (Norman, 1990). Thus, if the chair was located in a room full of professional wrestlers, perhaps the individual would perceive the chair not as an object for sitting but as a potential weapon.

Similarly, researchers of teacher cognition emphasized how individual teachers perceived certain objects or situations in their schools or classrooms in conjunction with particular responses or instructional strategies (Leinhardt & Greeno, 1986). Over time educators will develop attunements or cognitive heuristics related to the constraints and affordances represented by objects, policies, behavioral norms, and social regularities in their schools and classrooms (Greeno, 1998; Lee & Porter, 1990). Some researchers pay particularly close attention to the role of designed objects or "artifacts" (such as curricular texts) in shaping how teachers make decisions, based on the idea that activity is mediated and transformed by the unique configuration of artifacts within a person's environment (Wertsch, 1991; Halverson, 2003).

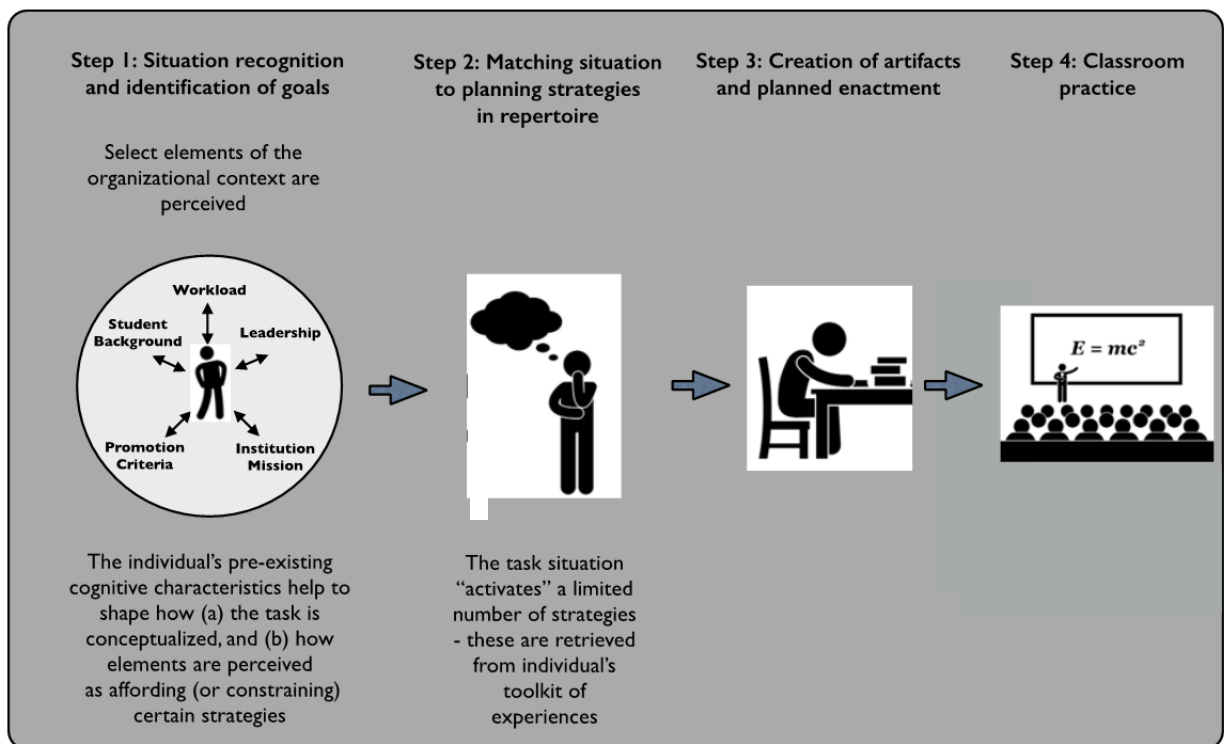
### **A New Approach to Studying Instructional Decision Making in Postsecondary Settings**

So what do the concepts of problem spaces, cognitive heuristics, and perceived affordances have to do with the issue outlined at the outset of the paper, namely how postsecondary faculty plan and then teach their courses, and subsequent implications for educational improvement? It is widely recognized that teaching situations are substantially

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influenced by contextual factors such as organizational policies or student background, and these contexts are often dynamic and evolving rather than fixed and stable (Borko, Roberts, & Shavelson, 2008). Recognizing the implications of this complexity for research on educational reform, Shavelson & Stern (1981, p. 461) argued more than 30 years ago that the field needs to understand teachers' goals, the nature of their task environment, their cognitive capabilities, and the relationship among these elements. More recently, Greeno (1998) encouraged researchers to focus on the specific processes whereby teacher's problem spaces are constructed and modified, and especially how perceived affordances play a role in shaping these processes. Yet, more than a decade later, little empirical research exists in this area and insights into the "actual decisions teachers make about course plans and curriculum" (Stark, 2000, p. 435) remain elusive.

In this paper I address this gap in the literature by focusing on four steps of the decision making process: (1) situation recognition—where the context is filtered down to essential components, (2) strategies or action steps for accomplishing the task, (3) curricular artifacts created, and (4) planned enactment of artifacts in the classroom. (See Figure 1.) Then, to determine how decisions translate into classroom practice, I examine how the process unfolded for two individuals.



**Figure 1. Model for construction of problem spaces during course planning**

This model is a starting point for elaborating the dynamics among individual decision making, the organizational and broader sociocultural contexts, and actual teaching practice. In this early stage of exploring these complex interactions I necessarily restrict the scope of the analysis to focus on the individual faculty and his or her teaching decisions. As such, this paper largely



ignores the critical influences of social dynamics, politics, and cultural narratives that comprise the academic field (Bourdieu, 1988; Trowler & Knight, 2000), the inclusion of which will be important for future research in this area.

### Methods

This study is a descriptive analysis of faculty practice in naturalistic settings. Practice-based research is increasingly common in educational research, particularly in regard to phenomenon where little is known about the salient variables at work and the dynamics between context and behavior (Bastedo, 2012; Halverson & Clifford, 2006). Such descriptive analyses of social action that are grounded in individuals' experiences and actions can shed light on subtle aspects of behavior that may generate new hypotheses, theory, and scientific insights (Flyvbjerg, 2006). This qualitative case study is uniquely suited to producing such rich, detailed accounts of practice. The cases analyzed are of the course planning and classroom teaching practices of faculty in math, biology, chemistry, geology, and physics departments at three large, public research universities. The method involves an intensive analysis of a single bounded unit (Yin, 2008).

The three study institutions were selected on the basis of the interests of the larger study from which this analysis is drawn—that of educational practice in science and math disciplines at the undergraduate level. The three institutions share similar undergraduate populations (approximately 25,000), education-research activities in science and math, and number of science and math departments. Science and math disciplines were selected for this analysis due to the nature of the larger study of which it was a part. This study was supported by the National Science Foundation and focused on the underlying influences of faculty teaching in these disciplines. While each of the institutions had active pedagogical reform initiatives underway at the time of data collection, one (Institution C) had a particularly active cross-departmental program to encourage interactive teaching among faculty. It is possible that these initiatives influenced the nature of faculty perceptions and teaching practices. The sampling frame for this study included 170 individuals listed in the Spring 2012 timetable as the instructor of record for undergraduate courses in math, physics, chemistry, biology, and geology departments at the study sites. Where multiple departments existed for one of these disciplinary groups, these were collapsed together for the purposes of this study. Individuals were contacted up to two times via email for participation in the study, and 58 faculty ultimately self-selected into the study. Information about the study sample is provided in Table 1.

It is important to note that data from the entire study sample ( $N=58$ ) were not used to address each of the research questions. For three respondents, answers to the freelist questions were insufficiently detailed to include in the analysis. For 11 respondents, answers to questions about course planning were not provided or were insufficiently detailed. The removal of these transcripts from the dataset thereby alters the composition of the study sample for the different analyses conducted in this paper. The three respondents removed from the freelist dataset were not included in the group removed from the planning dataset. Finally, for the in-depth case analyses I examined the interview and classroom observation data from a subsample of two

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respondents who exhibited similarities in discipline, appointment type, and class size and course level. Given the considerable influence of factors such as course content and class size on planning processes (Stark, 2000), I selected respondents for the in-depth analyses who shared these characteristics in order to minimize the potential sources of variability in their behaviors.

**Table 1. Description of sample by institution (interviewees)**

	Total	Institution A	Institution B	Institution C
<b>Total</b>	<b>58</b>	<b>20</b>	<b>18</b>	<b>20</b>
<i>Sex</i>				
Female	25	11	5	7
Male	23	9	13	13
<i>Discipline</i>				
Math	14	4	4	6
Physics	9	3	4	2
Chemistry	9	4	3	2
Biology	14	4	5	5
Earth/space science	12	5	2	5
<i>Level of course</i>				
Lower division	36	10	11	15
Upper division	22	10	7	5
<i>Size of course</i>				
50 or fewer	22	7	6	9
51–100	8	1	3	4
101–200	21	11	4	6
201 or more	7	1	5	1
<i>Position type</i>				
Lecturer (non-tenure track)	25	11	4	10
Assistant professor	9	4	3	2
Associate professor	3	3	0	0
Professor	21	2	11	8

### Data Collection

The data collected for this study include semi-structured interviews and classroom observations. Interview data were analyzed for the entire study sample of 58 faculty, whereas observation data were used only for the two participants in the in-depth analysis. All data were collected by three analysts who underwent training in the research protocols prior to fieldwork.

**Semi-structured interviews.** The interview protocols comprised two components: a freelist exercise and a series of questions about the teacher’s decision-making processes. First, the freelist exercise was intended to elicit those factors that respondents consciously considered the most influential in shaping course planning. The freelist technique is commonly used in cognitive psychology and cultural anthropology research, especially to identify “emic,” or insider, cultural domains in ethnographic fieldwork (Bernard, 2011). This contrasts to an “etic,” or outsider, account, which could describe much of the prior work in this area. The method assumes that when people report terms they do so in order of familiarity and cognitive salience,

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and that terms will most commonly reflect locally important items (Romney & D'Andrade, 1964). Researchers recommend that freelist prompts focus on a single mental category or domain in order to delimit potential responses (Quinlan, 2005), and in the data gathering portion of this study the three researchers focused on course planning for undergraduate classes. The prompt for the freelist was:

Please list all of the things that come to mind that influence you as you plan a specific lecture or class at the undergraduate level, using only single words or phrases. For example, the things that influence how a tomato grows could be sunlight, good soil, fertile seeds, and so on.

Some respondents answered the freelist question in complete sentences, whereupon the interviewer reminded them to provide only single words or short phrases.

Second, we asked the respondents questions about how they planned for a specific class using a variation of the critical decision-making technique (Crandall, Klein, & Hoffman, 2006; Klein, 2008), which essentially is a retrospective think-aloud technique to elicit details about how a decision was made in a specific situation. An important feature of this approach is the use of in-depth probes (e.g., specific decision points, cues noticed during decision making) to examine subtle features of decision making that may not be reported by respondents during a concurrent think aloud (Feldon, 2010). For this study respondents were asked to report their specific steps while planning for a class that our research team would observe that week. Follow-up probes to respondents' answers included questions about any situational cues that influenced the decision, any curricular artifacts that resulted from the planning process, and if and how these artifacts would be used in their actual classroom teaching. Interviews lasted 30–45 minutes and were digitally recorded.

**Classroom observations.** The Teaching Dimensions Observation Protocol (TDOP) is a classroom observation instrument developed to produce fine-grained descriptions of instructional practice (See Hora & Ferrare, 2013). The version of the TDOP used in this study captured five different dimensions of teaching practice: teaching methods, pedagogical strategies, student-teacher interactions, cognitive engagement, and use of instructional technology. Within each dimension there exist several detailed codes that observers capture at 2-minute intervals in real time. Prior to gathering data in the field, the three researchers established a common understanding of each code through rigorous training that included in-depth discussions about the meaning of each code category and individual codes, practice coding of videoed class segments, and, finally, the testing of inter-rater reliability.

### Data Analysis

Analytic techniques included saliency analysis of freelist data, thematic analysis of interview data, and thematic network analysis of the sequence and structure of decision-making processes for two respondents. Analyses described in this section were conducted by the author and another member of the research group.

**Saliency analysis of freelist data.** Freelist data can be analyzed in a variety of ways, including how frequently terms were mentioned, the position of terms, or the salience of terms that accounts for both frequency and position. For this analysis, we calculated the salience measure and used it as the primary indicator for situational recognition by respondents. Before conducting the analysis, it was necessary to prepare the data. This involved reviewing interview transcripts to ensure that respondents provided useable data for the freelist (i.e., single words or short phrases). Three respondents failed to discuss influential factors at all in their interviews and thus their data were not included in the analysis. In addition, 23 respondents provided information on these topics in sentence form, and not single words or short phrases. In these cases, it was necessary to identify passages where respondents answered the freelist prompt and to distill their more expansive observations into single words. To do this, two members of the research group met and engaged in a process of data reduction, which entailed an open-coding process whereby new codes or terms were derived from the data (Bernard, 2011; Miles & Huberman, 1994). Ideally, freelist data are provided solely in the form of single words or short phrases, but in this case an additional analytic step was necessary.

Then, because respondents listed terms that could be considered closely related but were in fact differently phrased (e.g., course material, content, and course content), a process of standardizing the terms was necessary. For this step, two of the analysts (including the author) reviewed the raw data and developed a list of terms that captured the intent of the entirety of terms provided. This involved making analytic decisions regarding the collapsing of multiple terms into a new term (e.g., course content). After we developed a final list, comprising 75 terms, we reviewed each respondent's list of terms to ensure consistency with the master list.

The finalized term lists were then organized according to the following groupings: the entire sample, by institution, and by discipline. We analyzed these lists using Anthropac (Borgatti, 1996), with the primary output measure being term salience for each of the groups. Salience is a commonly used metric because it suggests that a term reflects a shared cultural domain, or information that is psychologically important and relevant for multiple members of a group (Romney & D'Andrade, 1964). A salience measure was developed by Smith (1993) to reflect a mean percentile rank for each term across all respondent lists, that indicated the degree to which a term was both frequently cited and the order in which it was reported. For each individual list of terms, the salience measure is computed as:

$$S = \left( \frac{\sum(L - R_j + 1)}{L} \right) / N$$

Where S is the average rank of a given term across all of the freelists in the study sample, weighted by the lengths of the freelists in which the term is found. In the formula, L=length of a list (e.g., number of items in a list);  $R_j$  = position of item  $j$  in the list of terms (first item is 1), and  $n$  = number of lists in the sample. The resulting score is the average percentile rank of a particular term across all of the respondent lists—the item's gross mean percentile rank (see also Smith & Borgatti, 1998).

**Thematic analysis of interview data.** Next, responses to questions about instructional planning were analyzed for all 58 respondents using an inductive approach to qualitative data analysis (Bernard, 2011; Miles & Huberman, 1994). The goals for this analysis were to discern the specific planning steps that respondents reported for their upcoming class, which curricular artifacts were produced (if any) as a result, and how these artifacts would be used in the classroom. To identify the planning steps across respondents, two of the analysts (including the author) independently reviewed a sample of ten transcripts and each developed a preliminary code list using an open-coding procedure. In reviewing the transcripts, we focused on sections where respondents answered the question about their planning. Below is an example of raw data reviewed during this analysis:

Before each day I go through and read through my notes from last summer and make sure I am fresh on the topic and I will [identify] another example problem or two that I have not used before, because some kids are repeating the class.

In creating the codes we attempted to capture higher-order categories related to planning actions, while also maintaining a close relationship to the fine-grained nature of the data. In this case, we identified a preliminary code of “reviewing old notes.” We then compared results and produced a revised code list, which was used to review another ten transcripts. At this stage of the analysis each successive instance of the code was compared to previous instances in order to confirm or alter the code and its definition (i.e., the constant comparative method) (Glaser & Strauss, 1967). We then assessed inter-rater reliability by calculating the percentage of agreement between the two analysts in applying the codes. The proportion of instances in which we both coded the same code relative to all instances was 94%. After another process of revising the codes, we compiled a final code list, whereupon I then reviewed the entire dataset using these codes. Reliability was ensured throughout the analytic process through regular meetings between myself and the second analyst, testing inter-rater reliability at different stages of the analysis, and careful documentation of the chain of decisions made that led to the final results reported in this paper. Using this same procedure we reviewed the transcripts to identify curricular artifacts and whether or not these artifacts were to be used in classroom teaching.

**Thematic network analysis of structure and sequence of decision making.** Finally, the interview transcripts and classroom observation data for the two individuals selected for the in-depth analysis were analyzed using the thematic network analysis technique. This is a structured approach for identifying relationships between concepts in a graphic and time-ordered fashion (Miles & Huberman, 1994), and is similar to the verbal analysis method of Chi (1997). The core of this analysis for this paper was the identification of the distinct steps that comprised the individuals planning strategies or actions. To identify these related steps the interview transcripts were analyzed to identify explicit statements regarding relationships among different planning steps. These relationships were identified through two criteria: (1) respondents’ statements that indicated a relationship among factors, and (2) analyst interpretation of associations among factors. For example, one of the faculty included in this analysis clearly stated that when planning for a class she first retrieved her PowerPoint slides, then consulted the

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news and research literature to identify any topics that should be included in the slides, and then made changes accordingly. These results were used to develop a graphic that depicted the planning steps that were reported as a class was being planned and taught.

Then, we created another graphic for each individual that included each of the datasets included in the analysis: (1) freelist results, (2) planning steps, (3) curricular artifacts and planned use, and (4) classroom observation data. We analyzed the classroom observation data for each of the instructors by calculating the proportions that a particular code was observed in relation to all possible 5-minute intervals. Taken together, the graphics show what I call the “decision chains” that represent the structure and temporal nature of instructional decision making at the individual level. At this important stage, it was clear that both respondent’s reported a similar decision step, that of note retrieval and fine tuning, and so the two visuals were linked. It is important to note that the resulting displays represent the accounts of only two respondents from the study and should not be extrapolated to entire departments or institutions within the study sample or viewed as definitive accounts of action and behavior within these administrative units.

### **Results**

In this section I report results for the different components of problem space construction for the study sample: situation recognition, actual planning steps, form of the curricular artifact and reported use of artifacts in the classroom. Then, for two individuals, I report how these processes unfolded in the context of a specific class, along with how they actually taught the class.

#### **1. Situation Recognition: Factors Involved in the Initial Stages of Problem Space Construction**

Results from the freelist exercise capture the specific features of the task environment noticed or perceived as influential to planning processes by the individual. It is important to note that the types of environmental factors viewed as salient were left entirely up to the individual, and responses included a wide range of factors such as organizational, sociocultural, and curriculum-related factors. Results are depicted in Table 2, showing the frequency with which were reported across all respondent’s lists, the average rank of the term across all freelists, and salience scores that measures both frequency and average rank. In the interest of space, only terms with salience scores over .10 are reported here.

Across the entire sample, faculty perceive time (.25) as the most salient organizational factor influencing their planning, followed by class size (.20) and course content (.20). These factors are notable by being relatively “fixed” or durable features of the environment that are established by departmental administrators and/or curriculum committees. The next most salient term was the consideration of which illustrations or examples to use in teaching from either memory or textbooks (.13), and a curricular concern about the course textbook itself, particularly in regard to how material is sequenced and arranged (.12). These data indicate that when faculty

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consider the course design task—that is, the first stage of problem space construction—they first think about these factors.

**Table 2. Freelist results by institution**

	Frequency (%)	Average Rank	Salience
<i>Total sample (N=55)</i>			
Time	26.3	1.33	0.25
Class size	26.3	2.93	0.20
Course content	24.6	2.50	0.20
Examples/illustrations	22.8	4.31	0.13
Textbook	15.8	3.33	0.12
<i>Institution A (n=20)</i>			
Time	36.4	1.00	0.36
Class size	40.9	3.00	0.30
Examples/illustrations	22.7	3.40	0.15
Course content	18.2	2.50	0.14
Student level	18.2	3.00	0.13
Student background	18.2	4.25	0.11
<i>Institution B (n=16)</i>			
Examples/illustrations	37.5	4.50	0.20
Student career/degree trajectory	25.0	2.75	0.17
Syllabus	25.0	4.25	0.17
Textbook	18.8	2.33	0.17
Course content	18.8	2.67	0.16
<i>Institution C (n=19)</i>			
Time	36.8	1.71	0.34
Course content	36.8	2.43	0.29
Class size	26.3	3.20	0.20
Making it interesting	26.3	4.20	0.14
Textbook	21.1	4.50	0.14
Pedagogical goals	21.1	4.25	0.12
Course level	15.8	3.33	0.10

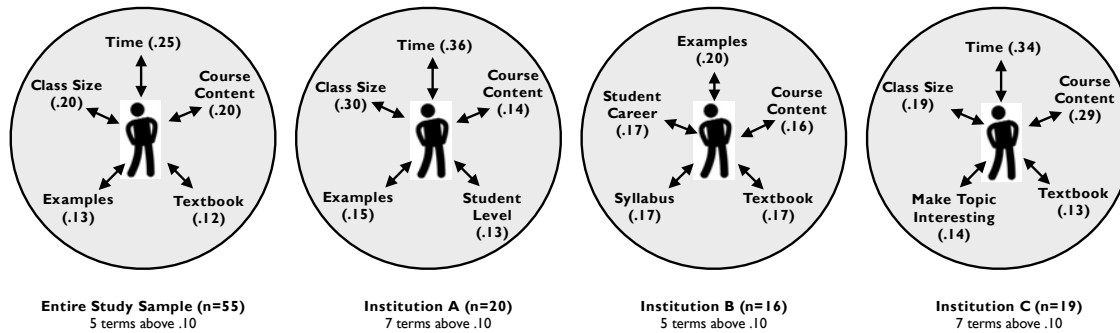
Note: Items with more than 10% salience scores are included in the table.

At Institution A, time (.36), class size (.30), examples and illustrations (.15), and course content (.14) were reported, all of which mirror the results from the entire study sample. However, two student-related factors were also reported: student level (.13) and student background (.11), which indicates that considerations about students enter into design considerations for this group of faculty at Institution A. At Institution B, illustrations and examples was the most salient term (.20), followed by student career trajectory (.17), syllabi (.17), textbooks (.17), and course content (.16). These data from Institution B are notable in the prominent roles that considerations of teaching techniques and students play in the problem space construction process. At Institution C, time (.34) was the most salient factor, followed by course content (.29), class size (.20), the pedagogical consideration of making the material

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interesting (.14), the textbook (.14), and course level (.10). In this case, the fixed constraints of time, content, and class size constitute the primary considerations for faculty at Institution C.

In order to visualize these results within the theoretical framework advanced in this paper, results from the freelist analysis for the entire sample and each institutional group are depicted in Figure 2, which visualizes the first stage of the problem space construction model.



**Figure 2. Stage 1: Situation recognition. factors involved in initial stages of problem space construction**

An interesting result is the institutional difference in terms of salience. While it is impossible to determine the precise source of this variability given limitations associated with the sample as well as the large number of potentially influential variables, one difference among the institutions that came across in the interviews was the active and highly visible pedagogical reforms initiative underway at Institution C. However, one could assume that such reforms may make faculty more cognizant of student and/or pedagogy-related factors. Yet, the institution where the fixed constraints are least salient (Institution B) is one where pedagogical reforms are less prominent than at the other two study sites. Thus, the source of the institutional differences cannot be addressed in this paper but remain an interesting problem to examine in future research.

During analysis, similarities and differences among the reported factors became apparent, so we conducted an inductive thematic analysis to ascertain if individual factors could be categorized into higher-order themes. The analysis revealed that individual items could be categorized into five groups: (1) organizational factors (e.g., time, class size), (2) curricular factors (e.g., content/topic, textbooks), (3) pedagogical considerations (e.g., pedagogical goals, making it interesting), (4) teaching techniques (e.g., examples/illustrations, assessment), and (5) student factors (e.g., student career trajectory). This structure was used in the remainder of the analysis.

### 2. Planning Steps: Specific Steps Taken by Faculty when Planning Courses

After the parameters of the problem space are identified, a limited number of actual planning steps are then “activated” for instructors. In conducting the analysis it became apparent that the five categories identified as factors from the freelist exercise (organizational, curriculum, pedagogical, teaching techniques, student) were evident in respondents’ descriptions of their



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planning steps; yet, in describing their actual behaviors, respondents discussed additional factors and strategies. New categories that emerged focused on actual strategies undertaken while planning as opposed to influential factors, including information retrieval (e.g., old lecture notes), information review (e.g., reviewing textbooks), artifact updating (e.g., revising old PowerPoint slides), artifact preparation, class preparation, and conducting post-class reviews. It was necessary in some cases to add nuance to the existing five categories as respondents discussed their behaviors at a finer level of detail. These included subdividing the category of teaching techniques into three parts: illustrations and examples designed to engage students and pique interest, problems or questions designed to elicit information, and the selection of instructional technology (see Table 3).

**Table 3. Most frequently reported planning steps by institution**

	All Sample	Institution		
	n=47	Inst A n=15	Inst B n=14	Inst C n=15
Information retrieval: Notes	23	8	7	8
Information retrieval: Slides	14	2	4	8
Artifact updating: Slides	14	4	5	5
Information review: Textbook	12	4	3	5
Artifact updating: Notes	12	4	2	6
Teaching technique: Problems or questions	11	5	3	3
Curricular factor: Main topic of class	10	4	3	3
Teaching technique: Illustrations or examples	8	4	2	2
Artifact preparation: Write lecture	7	1	5	1
Class preparation: Rehearse lecture	7	2	3	2
Pedagogical considerations: How to best present material	6	2	0	4
Curricular factor: Point in the syllabus	6	0	4	2
Curricular factor: Link to previous class	6	1	2	3
Teaching techniques: Instructional technology	5	2	3	0

At this stage of planning curricular artifacts play a particularly influential role. In fact, the five most frequently reported planning steps directly involved the retrieval, updating, or review of a curricular artifact. While some degree of institutional and disciplinary variation is evident, more attention is paid to these differences in the next section that focuses on the artifacts themselves. This is because the source of the variation appears to be largely based on the nature of the artifact and not necessarily the planning step itself. Furthermore, some planning strategies such as retrieving premade artifacts seem to be “activated” across the entire study sample. This suggests that some planning strategies are commonly used regardless of how the institution or discipline influences the initial construction of the problem space (i.e., situation recognition) as well as the nature of the curricular artifacts themselves. In the following section, the five most frequently reported planning steps are briefly described.

**Information retrieval: Notes and slides.** Many faculty in the study sample reported that in planning for a class they retrieved existing information in the form of two types of curricular artifacts: lecture notes (23 respondents) and PowerPoint slides (14). In both cases, these artifact types had been created in previous years, and preparing for the current term involved retrieving

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them from a file cabinet, desk drawer, or computer. As one geoscience instructor noted, all of her materials are “in the can” and just need to be retrieved annually. She taught the same course on a regular basis, so she viewed retrieval of the artifacts as both sensible in terms of time management and as a valuable resource that should be reused.

**Artifact updating: Notes and slides.** Another frequently reported planning step is making updating PowerPoint slides (14) or lecture notes (12). Respondents used terms such as “fine tuning” or “tweaking” to describe this step. Updating included making topical changes based on new research, altering activities based on recollections about what worked or did not work in prior terms, and changing artifacts based on changes in the textbook or syllabus. For example, one geology faculty stated that, “For Wednesday’s lecture I will use part of the material that I had last year, but every year I tend to change and tune it as I can see that some concepts need more time than I expected; it’s mostly a rephrasing as I can see the students reacting to my lectures, so it’s more of a fine tuning.”

However, this planning step only holds true if the instructor has taught the course before, or if he or she is new to a course but inherited materials from the previous instructor. In other instances where a new course must be created, a substantial amount of work will need to be invested in creating a syllabus, gathering materials, and so on. It is this investment of time and energy into curricular artifacts that made some respondents more inclined to engage in fine tuning each year rather than conduct a major revision or overhaul to their courses.

**Information review: Textbook.** Respondents (12) also discussed reviewing information in another type of curricular artifact—the textbook—as an important planning step. In these cases, prior to the beginning of the term, or immediately before a specific class, the respondent read through the relevant chapters in order to refresh his or her familiarity with the course material. In most cases a text authored by another scholar was an important reference point during the planning process. However, in one instance a respondent had written a textbook in her field but did not reference it because it “was all in my head” and thus did not require consulting with any external curricular resource.

**Teaching technique: Problems or questions.** Several faculty reported considering what types of problems or questions to include in a given class as one of their planning steps. This entailed identifying good problems to work out on the chalkboard, thinking of “thought-provoking questions” that would engage the class, or selecting questions for use in clicker-response systems. In this step, the instructor thought about and then identified problems or questions that illustrated the topic at hand while simultaneously leading students to engage with the material in a thoughtful and substantive manner.

**Curricular factor: Main topic of class.** Ten respondents noted that the main topic of the class was an important part of their planning. That is, in response to the question about how they planned the course, they reported a step of simply thinking about the topic being taught. Thus, considering the course material itself became an important planning strategy.

### 3. Curricular Artifacts: What Is the Physical Form of the Plan for a Particular Class?

As noted, the artifacts people use while planning are important because they shape activity by mediating the translation of intention into practice (Wertsch, 1991; Lave, 1988). Furthermore, the results reported thus far underscore the important role that curricular artifacts such as lecture notes play in the planning process, and so the next issue to probe is to what degree these artifacts are enacted in the classroom. The results indicate that plans for faculty in the study sample primarily take two physical formats: paper lecture notes (23 respondents) and PowerPoint slides (22). In addition, eight faculty reported using a combination of both lecture notes and slides (see Table 4).

These results highlight the dominant use of these planning forms and indicate their entrenched use in academic settings. Given the importance of the enactment process whereby a static artifact is used to support or otherwise mediate action in the classroom (Remillard, 2005), it is useful to explore the three ways that respondents discussed artifact use: no role in their teaching, role in the classroom, and role outside of the classroom (Table 4).

**Table 4. Artifact types and planned enactment by discipline (n=47)**

	Institution			
	All Sample n=47	Inst A n=15	Inst B n=14	Inst C n=15
<b>Artifact Type</b>				
Paper notes	23	8	8	7
PowerPoint slides	22	8	7	8
Combination of note types	8	0	3	5
Textbook	4	3	1	0
Word documents	3	2	0	1
Course manual	2	2	0	0
No notes	2	0	2	0
Pdf/tablet notes	1	1	0	0
<b>Planned enactment in class</b>				
<i>Has notes but no role in class</i>	3	0	3	0
<i>In-class role</i>				
Teaches from PowerPoint slides	11	2	4	5
References while speaking	7	0	5	2
Uses only for board work	5	3	2	0
Uses notes with blanks	3	2	0	1
<i>Out-of-class role</i>				
Posts online	8	5	2	1
Rehearses before class	7	3	1	3

First, three respondents noted that while they prepare lecture notes they do not bring them into the classroom. For these individuals, developing the curricular artifact was a way to get their thoughts on paper and to outline a sequence of topics or problems for an upcoming class, such that the purpose of creating the artifact (i.e., lecture notes in these cases) was preparatory and not

for use in the classroom. Second, 26 respondents discussed their use of artifacts (i.e., lecture notes and PowerPoint slides) in the classroom in various ways, including teaching directly from slides (11), using notes as a reference while speaking (7), for copying problems onto the board (5), or for using premade slides with blanks to fill in during class (3). In these cases, the notes or slides play a considerable role in guiding instruction because it is more or less directly “translated” from artifactual form to activity. Third, 15 respondents reported that their notes or slides play an important instructional role but not directly in the classroom. In these cases, eight faculty post their slides or notes on the course website prior to class and seven rehearse their lectures before the class period. Some respondents discussed using multiple strategies, so these data do not represent mutually exclusive approaches to artifact use. For example, one respondent prepares slides of calculus problems with blanks in certain areas, posts these online before the class, and during class engages students in collectively solving the problem.

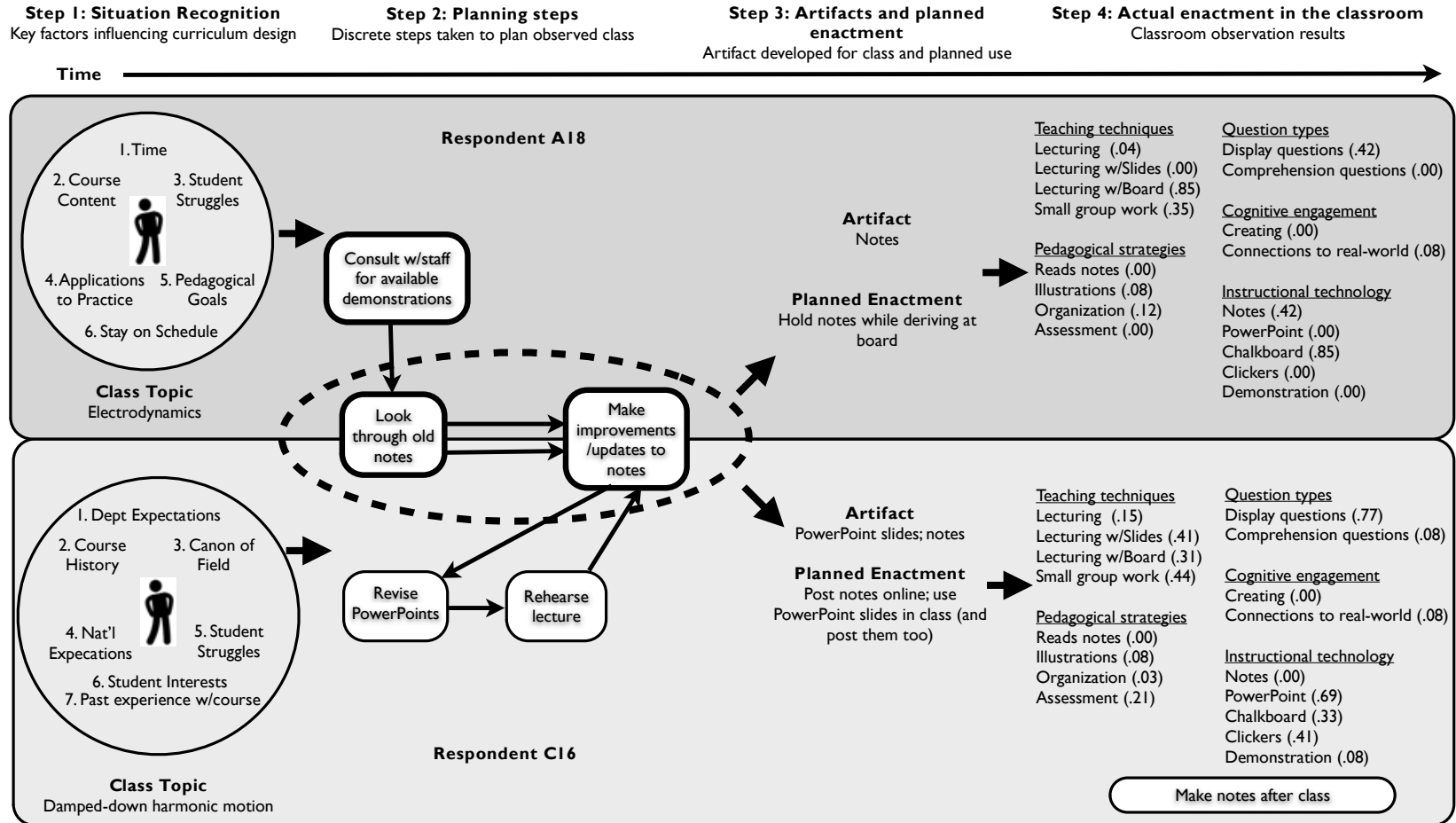
#### **4. Two Cases of Curriculum and Instructional Practice: Two Tenure-track Physicists Teaching Medium-sized Upper Division Courses**

To examine how the processes of problem space construction action unfold in real-world settings, I examine in greater detail how two instructors planned and then taught a class. The results from these cases, as they map onto the model of problem space construction advanced in this paper, are depicted in Figure 3.

**Chiyoko.** “Chiyoko” is an assistant physics professor at Institution A. The course discussed in the interview conducted for this study was on electrodynamics, and the syllabus was largely based on Griffith’s electrodynamics text. It was a junior level course, and Chiyoko observed that clickers were not necessary because the class wasn’t overly large, and no resources were available to do a more hands-on tutorial or demonstration-based class. When asked to list the factors that most influenced her course-planning activities, Chiyoko reported the following: time, course content, student struggles, application to practice, pedagogical goals, and staying on schedule. These factors thus represented the parameters of the course design problem space for this particular instructor.

The impact of the first term (i.e., time), and the pressure that it put on her personal goal of ensuring that students were directly engaged with the material, became clear when she began to describe her approach to teaching. Chiyoko stated that she was “trying to do the poor man’s thing of how do you involve students without killing me on time and feeling like I am constrained into a lecture format.” She then elaborated on how time considerations, as well as the required course content, did not co-exist particularly well with her pedagogical goals, stating that basically she was “trying to get through the material in the class and staying on the syllabus schedule, while also trying to read where students are having trouble.” In these remarks about time constraints, she made clear that she was referring to both the limited time she had available

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**Figure 3. Two instructors mapped onto a problem space model**

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in her job writ large, as well as the time constraints within a 50-minute class period. Then, her focus on identifying how students were doing in the course was grounded in her attempt to get students to “conceptualize problems beyond the math,” especially for the large group of students who were neither high achieving or interested. With the problem space of planning and teaching thus established in terms of time constraints and considerations about the content and student learning, Chiyoko then described how she went about planning for a specific class.

The first step she described in planning for the observed class, which was on electrodynamics, was to consult with the person who coordinates demonstration equipment in her department to see what equipment was available. Then Chiyoko looked at her old notes and updated them based on new developments in the research literature or the news that may be of interest to students. Thus, her planning steps for the observed class centered on consulting with departmental support staff, retrieving old notes, and fine tuning them.

This process culminated with a revised version of her lecture notes. These notes played an important role in the classroom, especially as she planned to work through a series of derivations in the observed class. As Chiyoko noted, “I’m not good at deriving without notes for the board, so I’ll actually hold my notes in my hand as I go through and put it on the board.” In the observed class, she spent most of the instructional time lecturing at the chalkboard (behavior observed in 85% of all 2-minute intervals), but also organizing students in small groups to discuss their work (35%). She also asked many questions seeking original answers (42%) as opposed to rhetorical questions, and directly referenced her notes frequently (42%).

In summary, Chiyoko’s conceptualization of the “problem” of planning and then teaching a class on electrodynamics was largely framed by concerns about time (both within the class period itself but also in her workload more generally), and covering the material in ways that satisfied both the pressures of the course syllabus and the needs of her students. The strategies that she then engaged in to plan the class included retrieving and fine tuning lecture notes, which in turn played an instrumental role in the classroom. Indeed, the key role that artifacts play in the planning process is evident in this case, with little to no translation between the artifact (i.e., lecture notes) and practice. Further, her pre-existing goals regarding student engagement were evident in the classroom through her use of small group work and regularly asking questions. In these ways, her teaching practices appear to be shaped by a combination of personal goals, situational constraints, and the curricular tools at hand.

**Gary.** “Gary” is a full professor who has worked at Institution C since 1993, where he has long been deeply engaged in physics education research. His situational awareness included references to departmental expectations, history or what was in the course before, canonical texts or what he called “universally known knowledge,” national expectations for physics education, student struggles and interests, and his past experience with the course. For Gary, concerns about the canon are the starting point for thinking about the curriculum in general and a specific class on harmonic motion. In addition to the other factors noted in the freelist exercise, he emphasized

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that his past experiences with the course play an important role, and that “you can’t help but have that influence” how the course is planned and then taught.

For the class being observed, which was focused on the topic of damped simple harmonic motion, Gary drew upon materials he developed the prior year. He taught the course a year before in collaboration with a postdoctoral student who was part of the teaching-reform effort at Institution B. The purpose of that intervention was to provide a postdoc for 2 years to work on a specific class to develop new curricular artifacts (e.g., PowerPoint slides, clicker questions, in-class activities) based on educational research in physics. A primary reason for focusing on creating high-quality artifacts was that the departmental policy for course rotations, which involved new instructors taking over several undergraduate courses every few years, essentially led to the wholesale recreation of the course based on the incoming teachers experience and views. Gary felt that by creating a “binder” of lecture notes, clicker questions, and detailed information about recurrent student misconceptions, the next instructor to take over the course would be more inclined to adopt (and adapt) these materials rather than creating entirely new ones whose quality would be unknown.

When mentioning “departmental expectations” as a key factor influencing his planning, he was thinking about the expectations for interactive teaching held by the local (and national) community of researchers involved in this pedagogical reform. Additionally, Gary had long been involved in education research in his field, based on a strong commitment to improving his own teaching as well as to his students. Thus, the problem space for Gary’s planning and teaching largely consisted of considerations about his students’ learning, the history and content of this particular course, and his colleagues’ expectations of what quality teaching looks like.

The plan for the class was to lecture for approximately half of the time, and to use interactive tutorials for the remainder of the period. The specific materials used for this class were inherited from the previous instructor, and included clicker questions, a course schedule, and lecture notes. In preparation, Gary reported that he “looked at my old lecture notes and PowerPoint slides, rewrote and reordered the slides, and stood at the blackboard (in my office) and went through the lecture portion.” He also has handwritten notes from the previous year for each class and usually revises them, but for the class being observed the notes were mostly in his PowerPoint slides and “in my head.” Gary also posted pdf files of his notes and slides on the course website.

During the observed class, Gary used a mixture of lecturing approaches (e.g., with PowerPoints observed in 41% of all 2-minute intervals, board work in 31%, and with no media in 15%) and small-group work (44%). He also used a considerable amount of assessments (21%) that were often carried out through verbal questions seeking original information (77%) and clicker technology (41%). These teaching behaviors were largely consistent with his self-reported plan, where the class would be half lecture and half tutorials. At no point was Gary observed using his notes, but his slides did serve an important organizational function by pacing the class and providing opportunities for questioning. Overall, the planning and teaching practices of Gary reflect a consistent thread from original recognition of the situation all the way through to classroom instruction. That is, his situational awareness of student learning of the

course material and related expectations of the education community acted as an overarching frame for how he approached the class. Then, because materials had already been prepared for the class based on strong considerations of student learning, planning involved retrieving, fine tuning, and then rehearsing these curricular artifacts. In this way, in retrieving these artifacts his actual planning practices were consistent with the rest of the study sample, but the problem space itself was framed more by student-related factors than by time constraints and his workload.

### Discussion

In this study I set out to describe how faculty plan and then teach their courses in real-world settings. The results indicate that a core set of fixed organizational and curricular factors are widely perceived as influential contextual affordances, with workload and attendant time limitations being particularly important in contributing to the routine maintenance of pre-existing artifacts (i.e., lecture notes and PowerPoint slides). In this section I elaborate on key aspects of these results, and discuss implications for current policy and programmatic efforts that encourage faculty to adopt interactive teaching techniques.

#### **A New Model for Faculty Practice: The Problem Space of Curriculum and Instruction**

Much like earlier work on curriculum design in higher education, which sought to identify all variables that influence the planning process (e.g., Conrad & Pratt, 1983; Lattuca & Stark, 2011), I too aimed to find those critical personal and contextual factors that appear to shape, if not dictate, how faculty plan and then teach their classes. However, this work differs from these earlier attempts in shifting the primary analytic focus from the omniscient observer who derives comprehensive models of the world, to that of the teachers' own perspective and experience. That is, the emphasis is placed on the actual views, perceptions, and experiences of individuals on the ground, or what anthropologists call the emic perspective.

This shift is informed by three developments. First, the critique that to account for all possible influences operating in real-world situations (both consciously perceived and tacitly influential) is nearly impossible and raises significant methodological concerns should not be ignored (Lee & Porter, 1990). Second, the evidence is clear that teachers make instructional decisions largely based on their own pre-existing cognitive frameworks that filter new information (e.g., new policies governing teaching), frame situations, and guide action (Shavelson & Stern, 1981; Fives & Buehl, 2013). Further complicating matters is the third development, namely that these cognitive frameworks are themselves influenced by the contexts in which faculty work, such that a wide range of factors (e.g., organizational, sociocultural, and personal) dynamically interact to shape instructional decision making (Greeno, 1998). This should dissuade researchers and policymakers from continuing to seek that single variable, or magic bullet, that will both single-handedly explain behavior as well as transform undergraduate education (Umbach, 2007). Instead, viewing the world through the eyes of instructors on the ground, and the more limited but influential combinations of variables influencing them, may be more productive in seeking to understand the dynamics of educational reform (Spillane, Reimer, & Reiser, 2002).



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The application of problem space theory as outlined in this paper results in such a grounded, emic account of faculty practice that builds upon these empirical and methodological developments in the field of educational research. In brief, the model outlines the processes whereby faculty construct the problem space of course planning, which is initiated first by actively perceiving a limited number of factors or conditions that are considered particularly salient to their work (e.g., class size). Once perceived, a variety of strategies or action steps occur to the problem-solver in relation to these factors in a process of successively narrower options (e.g., no small group work for large classes) that ultimately leads to the development of a curricular plan and then enactment in the classroom. I suggest that this model opens up the black box of instructional decision making, particularly the subtle dynamics among actor, situation, and artifact that comprise faculty practice “in the wild” (Halverson & Clifford, 2006). Insights into these complex phenomena can be used to improve educational leaders’ understanding of faculty work and, consequently, the design and ultimate efficacy of teaching-related interventions.

Nonetheless, this work is in its early stages of conceptual and methodological development, and several limitations are immediately apparent. Perhaps most pressing, given the importance of cultural forces in academia that govern norms for teaching and the nature of knowledge itself (Clark, 1983; Tierney, 1988), is the prospect that too much explanatory power may be placed on individual agency and conscious sense-making processes, which serves to obscure the influence of the cultural context and its subtle or tacit influence on individual and group action. A theoretical stance that foregrounds the impact of the cultural context on behavior is provided by field theory, which is often explained in terms of a game, where the field of activity is governed by both explicit and tacit rules that all players recognize and follow when making decisions (Martin, 2003; Winkle-Wagner, 2012). Thus, behavior is largely based on how an individual perceives a particular culturally organized field of play, and which of its delimited number of subsequent options are most optimal in a given situation. The intersection between field theory and a more cognitivist approach as outlined in this paper represents a potentially productive area of future research that could elaborate the role of culture in instructional decision making in a theoretically robust way.

In the remainder of this section I focus on three key elements of instructional decision making that seem particularly influential in shaping how faculty think about and then actually plan and teach their courses. Then, I explore the relationships among these decisions, curricular artifacts, and classroom teaching, followed by implications of this study for policy and practice.

### **The Dominant Features Perceived to Shape the Problem of Planning**

When they considered the factors most salient to their course planning activities, faculty in the study sample most frequently reported a set of factors that could be considered “fixed,” or somewhat non-negotiable features of their organization’s operations and policies. These factors included time, course content, and class size, each of which are linked to workload obligations, course curricula, and departmental policies governing course size, respectively. As such, the problem space for planning is demarcated less by idiosyncratic or context-free considerations such as personality or pedagogical beliefs, and more by an awareness or attunement to what is

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demanded by and possible within the existing organizational context. This is not surprising, given evidence that teachers' generally view their adoption of new policies or innovations, such as interactive teaching techniques, through the lens of what is feasible and desirable within their current workplace (Coburn, 2001; Henderson & Dancy, 2007).

However, the results also suggest that the role played by fixed organizational affordances in how faculty construct the problem space for teaching is not dominant across all institutions or disciplinary groups included in this study. For example, at Institution B the most salient factors were teaching techniques (i.e., examples and illustrations) and student factors (i.e., student career or degree trajectory). Further, disciplinary variations were observed. The most salient factor for physicists was departmental expectations, for biologists pedagogical goals were critical, and for chemistry faculty the background of students was reported as the most salient factor. Thus, it appears that the factors perceived as salient vary as one gets into smaller organizational units, each of which operates within its unique institutional and sociocultural context.

These results differ from research on this topic conducted more than 20 years ago, where Stark (2000) found that the contextual factors viewed as most influential in regard to course planning included student-based topics such as student characteristics (e.g., ability and level of preparation) and goals. These considerations of students were followed by what Stark (2000) called "pragmatic issues" that included class size, followed by factors such as influences external to the college (e.g., accreditation) and college goals. In contrast, faculty in the current study exhibited a relatively low saliency for student-based factors as one of the key elements considered while planning. With the exception of Institution B, faculty report the salient features of the problem space for course planning as being exclusively comprised of non-student factors.

Some interesting questions arise from this finding. What are the implications of a planning process that omits a deep consideration of student needs and abilities? Is it preferable to have faculty think about their students when planning a course, and, if so, why? In the case of Chiyoko, her personal goal to engage the "middle" group of students who were neither high nor low achievers, along with a focus on student struggles with particular topics, certainly appeared to have shaped how she designed her classes and selected activities in a way that led to an active and engaging classroom. At the very least, it seems that some consideration of students during the planning process, as is evident in approaches such as backwards design or problem-based learning, contributes to instruction that is well aligned with the interests and aptitudes of a particular group of students. The relative absence of student-based factors in the study sample may be indicative of a population for whom other factors, particularly that of time and related workload constraints, enters into their thought process more readily and easily.

### **The Centrality of Time Constraints and Implications for Routine Maintenance**

A major finding from this study pertains to the centrality of time constraints on how faculty perceive their own work and the concomitant possibilities (or lack thereof) for instructional improvement. To a person the faculty participants in this study were extremely busy professionals with many competing demands on their time such as running labs, mentoring

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students, and teaching both graduate and undergraduate courses. Even for those not on the tenure track for research-intensive positions, many lecturers in the study were involved in educational research activities or otherwise engaged in research-related pursuits. All told, for this population, time was a particularly valuable and scarce resource.

As perceived affordance theory suggests (Greeno, 1994), over time teachers will become attuned (and even habituated) to desirable and feasible courses of action related to particular cues or situations, and which cues in the environment should be given more or less attention. So how does this perceived affordance influence practice? First, it contributes to the reliance on a planning and class preparation strategy that involves the least amount of time—that of fine tuning or tweaking existing materials, a strategy that Stark (2000, p. 420) called “routine maintenance.” Maintenance often involves improving problem sets, integrating new teaching strategies or activities, or updating the course material in light of new scientific discoveries. This entrenched strategy is altered only in certain circumstances, such as when a course is brand new and requires an entirely new curriculum, instructors are strongly dissatisfied with a course, or when a new instructor comes into a course. These results are consistent with Stark’s findings from more than 20 years ago, which suggest that the routine maintenance of curricular artifacts is a deeply entrenched cultural practice among postsecondary faculty in research universities.

What are the implications for this reliance on fine tuning existing materials? The answer to this question depends in part on the quality of the materials and whether or not they are designed with attention to not only the rigorous presentation of content but also to engaging presentation, the scaffolding of material from less to more complex, and other principles of effective teaching. If poorly conceived syllabi or activities are created, stored, and annually retrieved, improvement to the teaching of the person using these materials is difficult to envision. Conversely, if the materials are of high-quality, even if a time-pressed instructor simply takes them out of the drawer an hour before class, it is possible the class will be more pedagogically informed than otherwise. A key to this process seems to be ensuring that the artifacts are well done, but therein lies the catch-22 for faculty, as preparing such materials requires a resource that is in short supply—time. This quandary was highlighted by a biology instructor who was a fulltime lecturer and deeply involved in biology education, and yet:

I would prefer to start every class period or every topic with an active exploration on [the student’s] part, culminating with some wrap up by me. But in practice there are some 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. And so it’s just time really on my part, [whether or not] I had time to develop some [materials] I think will actually get them going. And if I haven’t had time to address that concept [or] to create some cool activity for them to do then I revert back to the old fashioned way of introducing the concept and then maybe writing some clicker questions that get them to think about it.

So for this instructor, who has the training, motivation, and position to implement interactive teaching as advocated by policymakers and educators, to actually prepare quality

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materials requires a substantial amount of time. Thus, even for faculty who are deeply committed to improving their teaching, within the parameters of their work and careers the routine maintenance of existing artifacts is simply a sensible and in some cases the only strategy.

In addition, if the workload and attendant time constraints are the primary lens through which teaching activities are viewed, there may also be implications for educational reform given evidence that new policies and initiatives are also “filtered” or interpreted through the cognitive frameworks of teachers on the ground. Thus, if the workload is sufficiently heavy to not reasonably allow for or accommodate the demands of a new policy (e.g., introducing clickers that require time for training and incorporation into the curriculum) it is unlikely to succeed unless something is done to alter the underlying organizational conditions and their corresponding perception of constraints and affordances for practice.

### **Does the Artifact Matter? Enactment in the Classroom**

The data indicate that curricular artifacts mediated the interactions between teachers and students in two important ways: as a guide to classroom instruction or as a study aid where notes or slides were provided directly to students. Once created and/or retrieved, the faculty enacted the slides and lecture notes in the classroom with varying degrees of fidelity to the original. For some, the notes were simply guides referenced every few moments but did not play a central role in teaching. For others, the notes included entire sentences or solutions to problems that were either recited verbatim or copied onto the chalkboard in their entirety. In both cases, the notes or slides acted as a reference point during instruction to ensure that the correct solutions and/or facts were conveyed and also to keep the instructor on schedule, which suggests that the form and content of the artifacts influences classroom teaching.

However, some situations or aspects of teaching may minimize the influence of artifacts. In some cases faculty reported walking into the classroom “cold” with no notes, materials, or evident preparation, which renders curricular artifacts unimportant and makes the instructor’s mental acuity the primary resource. For example, the geologist who wrote the primary textbook in the field said that everything was “in my head” and her classes on a given day were guided by a combination of the syllabus and her mood and inspiration. Yet, this approach to teaching was not common in the study sample; even experienced instructors emphasized the importance of well-designed artifacts and preparation in order to ensure their peace of mind as well as the quality of instruction. Additionally, several faculty emphasized the performative aspects of teaching, such that even in cases where multiple classes were taught using the same set of artifacts the classes could substantially differ in tone and composition depending on the student body or the instructors’ mood. This is especially the case in regard to the different types of questions students may pose, and the resulting conversations or discussions that may ensue. Thus, the human dynamic and subtle features of communications between teachers and students should not be ignored when considering how artifacts mediate classroom teaching.

## Implications for Policy and Practice

Besides contributing new empirical insights into instructional decision making and curricular design in postsecondary settings, the results reported in this paper have implications for educational practice and change. Before proceeding with this discussion, it is important to revisit the fact that multiple factors shape how teachers plan and teach their courses such that no magic bullet or single factor (e.g., tenure and promotion criteria) can be altered to transform or predict practice. This fact alone should dissuade the field from continuing to seek that single variable or policy that will transform undergraduate education. Instead, much is gained in obtaining a realistic and multifaceted understanding of how faculty think and act in their workplaces, an understanding that can be used as an instructional guide of sorts that practitioners and policymakers alike can use to design new programs that are more aligned with local practice than not (Umbach, 2007; Helman, 1997; Rogers, 1995). The framework outlined in this paper provides a conceptual lens that, if used to diagnose or study how faculty navigate their organizations when planning and teaching their courses, could reveal particularly propitious variables or “levers of change” that, if altered or supported, may result in changes to practice (Spillane, Halverson, & Diamond, 2001; Cobb, Zhao, & Dean, 2009).

The main result reported in this paper that can reasonably be thought of as a potential leverage point for change is that of time constraint and its relationship to the strategy of routinely fine tuning existing notes or slides. Given that the academic workload is unlikely to change in the near future such that more time is available for course preparation, and even may get more demanding in terms of responsibilities and obligations expected of both tenure-track and contingent faculty, I suggest that in seeking solutions to the potentially short-sighted habit of routine maintenance of notes and slides it is instead more tenable and feasible to ask faculty to do one simple thing, namely to engage in a practice described by three different instructors in this study: take notes immediately after class about what worked and what did not work in terms of teaching style, activities, sequencing of material, and so on. Upon describing this practice and being asked if she wrote these notes in her office after the class, one biologist stated that:

No, I do not have that much time. I can tell right during the lecture that things are not working, and in the few minutes that I am packing up after lecture, I will make a note right on the printout of the PowerPoint slides.

This respondent then goes on to state that this was an effective practice only because she was well organized and has a notebook containing all materials required for teaching the course, including the syllabus, attendance records, notes about individual students, and printouts of slides for each lecture. Thus, when notes are made on the slide printout, when she teaches the course the next semester she will immediately see and reflect upon the new observation and incorporate that into the next iteration of the class.

While this brief and even cursory reflection about their teaching is not exactly what is recommended by those who advocate reflective practice as a cornerstone to improving professional practice in general or teaching in particular (e.g., Schon, 1983; Jay & Johnson,

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2002; Kane, Sandretto, & Heath, 2004), given the fixed constraints perceived by today's faculty members in regards to their workload and attendant priorities, it is unfortunately not likely that postsecondary teachers will be able to allocate hours to keeping a teaching journal or consulting with a faculty developer. Instead, asking or even requiring faculty to make brief observations of how each class went would represent an important step in developing a sense of reflection and, ideally, continuous improvement in their practice.

The prospect of making such reflection on the success or failure of the course a departmental policy was actually raised by a respondent, who observed that his departmental chair did not require a post-course write up about how the semester went, but that "maybe he really should." Ideally, these reflections would directly lead to updating the instructor's lecture notes and/or PowerPoint slides for the following year or semester, in which case the benefits of the brief period of reflection would be twofold: improved curricular artifacts and an instructor who is beginning to become a reflective practitioner. Would this be asking too much of already over-burdened faculty to respond to yet another administrative task? Perhaps, but the benefits of engaging in reflective practice outweigh the potential backlash that departmental leaders may receive. In requiring faculty to think and write about their teaching efficacy, their notion of the problem space for teaching could potentially be extended beyond the immediate and habituated factors of time and content to encompass additional considerations of pedagogy and student needs.

### **Conclusions**

The traditional manner of teaching and conveying knowledge and skills to the next generation is changing in the face of digital technologies and prodigious efforts to encourage faculty to become less of a "sage on the stage" and more of an engaged mentor with a diverse pedagogical toolkit. Such developments raise the prospects that the multifaceted factors that faculty must negotiate in their work will only increase, and attempts to both understand and change how they plan and teach courses will become correspondingly more complex. Adding to the challenging nature of attempting to discern the "causes" or "determinants" of behavior is the fact that much of social action is shaped by tacit or subconscious compliance with the unspoken rules of the game (Martin, 2003; Greeno, 1998). Thus, any attempts to model the key features that shape faculty sense making and subsequent strategies for their teaching-related work must proceed cautiously and with careful attention to the limitations of such an approach and the theoretical insights offered by other lines of inquiry pursuing similar topics, such as naturalistic decision making (Klein, 2008), figured worlds theory (Holland, Lachicotte, Skinner, & Cain, 1998), and field theory (Martin, 2003). Ultimately, researchers and policymakers engaged in educational improvement at the postsecondary level will need to recognize that individual faculty—and the variety of cultural spaces they inhabit—cannot be managed or controlled, which was and remains a dominant way of thinking in regard to organizational improvement (e.g., Martin, 2002). Instead, to advance the quality of undergraduate education within the existing structures and cultural systems at play in colleges and universities across the United States, policymakers and practitioners must strive to find that critical balance between "best practices" and the lived experiences of faculty on the ground.

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