Understanding the Factors that Support the Use of Active Learning Teaching in STEM
Undergraduate Courses: Case Studies in the Field of Geoscience

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Dedication

This dissertation is dedicated to the memory of my father, Howard Roscoe.

Abstract

The purpose of this study was to understand the factors that support the adoption of active learning teaching strategies in undergraduate courses by faculty members, specifically in the STEM disciplines related to geoscience. The focus of the study centered on the context of the department which was identified as a gap in evaluation and educational research studies of STEM faculty development. The study used a mixed-method case study methodology to investigate the influences of departmental context on faculty members' adoption of active-learning teaching practices. The study compared and contrasted the influence of two faculty development strategies initiated in the field of geoscience. Six university geoscience departments were selected that had participated in two national geoscience professional development programs. Data were generated from 19 faculty interviews, 5 key informant interviews, and documents related to departmental and institutional context. The study concluded that two main factors influenced the degree to which faculty who participated in geoscience faculty development reported adoption of active learning pedagogies. These conclusions are a) the opportunity to engage in informal, regular conversations with departmental colleagues about teaching promoted adoption of new teaching approaches and ideas and b) institutional practices regarding the ways in which teaching practices were typically measured, valued, and incentivized tended to inhibit risk taking in teaching. The conclusions have implications related to institutional policy, faculty development, and the role of evaluation.

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Chapter 1: Introduction and Problem Statement

Background

Thirty years ago, the National Science Board[1] commissioned a year-long study to evaluate and characterize the state of undergraduate education in science, technology, engineering, and mathematics (STEM) (National Science Board, 1986). From the study, the commission identified specific areas of concern, including a high percentage of undergraduates who were lacking basic levels of scientific, technological, and mathematical understanding. The National Science Board stated that improved levels of understanding were needed in order for graduates to make informed decisions in their professions and as citizens engaged in their communities. Without this basic understanding, leaders and policymakers feared that the workforce would not be equipped to respond appropriately to issues that would be encountered in the future and would require knowledge of science, technology, engineering, and mathematics. The challenges they anticipated included changing information systems, water and energy constraints, ozone depletion, and evolving healthcare practices and policies.

The commission identified a need to improve the quality of undergraduate STEM instruction across all institutions. The report and additional studies (NSB, 1986; Office of Undergraduate Science, Engineering, and Mathematics Education (USEME), 1988; American Association for the Advancement of Science (AAAS), 1989; Boyer, 1990; National Research Council (NRC), 1996; NSF, 1996; NRC, 1997; NRC, 2002; NRC,

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[1] The National Science Board consists of leaders in science and engineering who are appointed by the President and confirmed by the U.S. Senate.

2005) all agreed on the need for the use of improved pedagogies as a means of improving undergraduate STEM education. These pedagogies, discussed in the literature as evidence-based teaching, scientific teaching, or active learning, demonstrate a new approach to bring the spirit of scientific inquiry into the teaching of science (AAAS, 1990). In a few cases the pedagogies have explicit protocols (e.g., SCALE-UP or POGIL), but more frequently researchers are referring to a broad set of active learning strategies which can include group problem-solving, small group discussion, personal response system methods, or peer instruction (Freeman et al., 2014; Docktor & Mestre, 2011; Macdonald, Manduca, Mogk & Tewksbury, 2005; Handelsman et al., 2004).

Seeking these types of improvements in teaching, the Science Board recommended that the National Science Foundation (NSF) should initiate comprehensive, national initiatives to improve undergraduate STEM education. As a result, policymakers have funded initiatives involving hundreds of millions of dollars in public funds through such granting organizations as the National Science Foundation, the National Oceanic and Atmospheric Administration, and National Aeronautics and Space Administration. Many of these initiatives included faculty development as a key strategy to foster a culture of teaching excellence (Sorcinelli, Austin, Eddy, & Beach, 2006).

Where active learning has been implemented in undergraduate STEM courses, numerous studies demonstrate greater student learning gains compared to courses where traditional lecture has been employed (Hake, 1998; Handelsman et al., 2004; Ruiz-Primo et al., 2011; Deslauriers, Schelew, & Wieman, 2011;Haak, 2011; Freeman et al., 2014;). The largest and most comprehensive meta-analysis included 225 studies of undergraduate

STEM courses comparing the use of traditional lecture to active learning teaching using either exam scores or failure rates. The meta-analysis found that students in classes employing a traditional lecture format were 1.5 times more likely to fail (Freeman et al., 2014). In comparison, student exam performance increased by 0.47 SD in courses employing an active learning format (Freeman et al., 2014). These results are comparable to earlier studies (Hake, 1998; Ruiz-Primo et al., 2011). However, in a national study of a random sample of undergraduate biology courses, more modest learning gains were reported in courses taught by instructors who lacked science education research experience. Instructors with science education research experience were defined as those faculty members who had attended workshops or conferences related to teaching or science education, published papers related to science education, or received funding that included aspects of educational research. The findings suggest that active learning teaching is not easy to implement. It requires professional development in active learning teaching techniques. Additionally, institutional support must also be strong in order to support classroom norms that are fundamentally different from traditional lecture class norms (Andrews et al., 2011).

Despite the ongoing investment in faculty development initiatives, evidence of change in teaching has been disappointing (NRC, 2012; President's Council of Advisors on Science and Technology, 2012). There is no consensus in the literature as to what may be inhibiting change. Some reviews of faculty development initiatives identify implementation failures (NRC, 2011b; Silverthorn, Thorn, & Svinicki, 2006; Penberthy & Millar, 2002; Clark, Froyd, Merton, & Richardson, 2004). Other studies assert that

programs are working as designed but are just not delivering the desired outcomes. These studies argue that better change theories are needed to underpin the rationale for more promising faculty development initiatives (Henderson, Beach, & Finkelstein, 2011; Kezar, 2011; Fairweather, 2008).

Recent evaluations of STEM faculty development programs provide little insight into the reasons for the limited adoption of active learning strategies. In a review of eight national STEM faculty development programs, all evaluations report high participant satisfaction. However, the sustained use of the active learning techniques by participants remains uneven (Hilborn, 2012). One evaluation in the physics community attempted to learn why faculty did not implement more of these pedagogies. They surveyed 722 physics faculty but responses provided only superficial insight. In response to the question, "What prevents you from using more-research-based instructional strategies?" over half of the open-ended responses indicated "time" with another quarter of the responses reporting a lack of familiarity with the pedagogies as the barrier (Dancy & Henderson, 2010). When participants report the use of active learning teaching, data from surveys of department chairs and video of participants' subsequent teaching fail to corroborate such changes in teaching (Ebert-May et al., 2011). Several reports identify departmental context as an important factor that may explain why some departments are more successful than others in implementing active learning pedagogies (Feig & Waterman, 2012; Froyd, 2012; Henderson, 2012; Hilborn, 2012). These reports argue that greater understanding into the process of adoption for active learning teaching would illuminate the reasons for program success and failure. These reports and additional

scholarly commentary suggest that attention to departmental and institutional

expectations as well as disciplinary influences are integral to explicating this process

(Hilborn & Howes, 2003; Hilborn, 2012; Graham, 2012; Wieman, 2009; Wieman,

Perkins, & Gilbert, 2010).

Despite the ongoing debate as to the causes of program failure, it is clear from

current levels of program funding solicitations (NSF, 2014; NASA, 2015) and reports

(AAAS, 2014; PCAST, 2012) that policymakers and granting agencies find faculty

development initiatives worthy of funding. Policymakers expect these initiatives to

catalyze changes in teaching that leads to more scientifically literate undergraduates. In

addition, policymakers presume a new set of outcomes for these initiatives which include

attracting greater numbers of STEM majors and increasing the diversity of students in

STEM (Maton, Hrabowski, & Ozdemir, 2007; NRC, 2007; NRC, 2011a; NRC, 2012;

PCAST, 2012; AAAS, 2014). The sustained and ongoing investment of public funding

suggests a need for a better understanding of the reasons for program success and failure.

Statement of the Problem

While researchers have not reached consensus as to why the adoption of active

learning teaching in undergraduate STEM education is not succeeding, there seems to be

some agreement that these pedagogies demonstrate evidence of greater student learning

(Freeman et al., 2014; Kuh, et al., 2005; Handelsman et al., 2004). A few studies suggest

that faculty find adoption of these pedagogies difficult and may require additional

training to achieve comparable student learning gains (Andrews et al., 2011; Dancy &

Henderson, 2010). Moreover, scholars identify the context surrounding a faculty member

(including their colleagues, departmental context, institutional structures, and disciplinary expectations) as an influence to teaching practice (Hilborn, 2012; Kezar, 2011; Kezar & Eckel, 2002; Fairweather, 2005, Henderson & Dancy, 2007). Despite agreement on these aspects, there remains a lack of understanding about what factors influence faculty adoption of active learning pedagogies. For evaluators this results in not having a clear understanding of the types of data that they should collect when evaluating programs intended to promote such adoption. As a consequence, existing evaluations tend to focus on weaker measures of success, such as participant satisfaction. Evaluations may arrive at mistaken conclusions due to inconsistent or incomplete data. Moreover, programs designed to influence faculty adoption of active-learning pedagogy remain less successful.

Context matters in evaluation. In the SAGE handbook of evaluation, Rogers and Williams (2005) assert that in order to understand how learning happens related to a program, evaluators need to examine how the program works within the wider organizational context. Greene (2005) argues that how context is conceptualized in evaluation theories and how it is engaged in evaluation practice, "fundamentally differentiates one evaluation approach from another"(p. 83). She includes institutional and organizational climate as one of five dimensions which define the setting within which a program is evaluated. Pawson & Tilley (1997) note that few programs completely fail and few work perfectly. For this reason, they argue that evaluators should examine the prevailing social context and processes. Context, they reason, can characterize why and how a program works or fails.

Recent evaluations of STEM faculty development fail to collect or report data related to participants' professional context and how context may support or limit adoption. Evaluations tend to focus narrowly on satisfaction and the self-reported adoption of specific active learning pedagogies (Ebert-May et al., 2011; Felder & Brent, 2010). Few evaluations consider how the context of the faculty (science discipline, institution type, or departmental context) influence faculty making changes in teaching practice. Teaching practice, like other human behavior, is shaped by the contexts in which it is situated (Bransford, Brown, & Cocking, 2000). This suggests that an evaluation which considers faculty context might provide additional insight into the reasons for program failure and success.

Understanding Faculty Contexts

Institutional researchers describe the context of faculty members in terms of the culture or climate to which faculty member belong. While culture, context, and climate are often used interchangeably in the higher education literature, scholars define culture as the "collective, mutually shaping patterns of behavior" within an organization and the "norms, values, practices, beliefs and assumptions" of its members (Kuh & Whitt, 1988, p. 12). Moreover, culture is viewed as bound to a specific organizational context. Scholars distinguish climate as a description of the current perceptions and attitudes by individual members about the practices and patterns of behavior within the organization (Peterson & Spencer, 1990).

Faculty members, like other education professionals, identify as members of different communities, each which may have an influence on their teaching practice.

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Austin (1990) describes four cultures to which faculty members may belong: 1) the academic profession itself; 2) the disciplinary culture; 3) the culture of higher education as a national system; 4) the specific institutional culture. How faculty members perceive teaching in relation to their academic profession may have an influence on the pedagogies they adopt. Faculty situate their academic identity in both their disciplinary and institutional culture (Kuh & Whitt,1988).

Influence of Departmental Culture on Teaching

There is a substantial body of literature related to the study of institutional culture and disciplinary subcultures (Kezar & Eckel, 2002; Tierney, 1988; Clark, 1984; Becher, 1981). Yet, departments as the organizing mechanism are less understood or acknowledged (Lee, 2007; Clark, 1984). Departmental culture can be influenced by both institutional culture and disciplinary culture. Consequently, it may be difficult to tease out its specific culture. A few studies have identified patterns of behavior in departmental cultures where focus is placed on improving teaching (Wright et al., 2004;Umbach, 2007; Massy, Wilger, & Colbeck, 1994; Knight & Trowler, 2000). These patterns characterize the collegiality and socialization practices within the department.

<center>**Purpose of the Study**</center>

The purpose of this study was to understand the factors that support the adoption of active learning teaching strategies in undergraduate courses by faculty members, specifically in the STEM disciplines related to geoscience. The focus of the study centered on the context of the department which was identified as a gap in evaluation and educational research studies of STEM faculty development. Departmental context is

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influenced by the institution in which it is situated. The disciplines of the faculty who comprise a department may also influence departmental context. Thus, both institutional context and disciplinary influences was considered in examining departmental context in the study. The knowledge gained from this study informs the evaluation methods and the types of data evaluators should use for programs intended to promote adoption of active learning teaching strategies. It also provides greater insight into the possible reasons such teaching strategies fail to realize widespread adoption.

The field of geoscience was selected for this study for several reasons. First, geoscience faculty members encompass an increasingly diverse set of disciplines (e.g., geology, meteorology, oceanography, climate science, environmental science and engineering, physical geography). No common curricular model exists. Instead, a diverse set of curricular models have been pursued that offer an opportunity to investigate the influence of a range of departmental and disciplinary factors. As will be described in greater detail in Chapter 2, the development and evolution of the geoscience curriculum appears to be at a crossroads. Geoscience departments have been forced to grapple with the challenge of balancing multiple teaching and curricular approaches. These include curricular interests rooted in traditional fields of geology interests and curricular approaches aimed to address the pressing challenges related to climate change and water and energy constraints.

Second, the geoscience disciplines have been the focus of numerous initiatives to promote active learning. A range of strategies have been pursued, providing an opportunity to compare and contrast the influence of these strategies. In response to

national studies (NSB, 1986; Boyer, 1990; NRC, 1996), leaders in the geoscience

disciplines established numerous initiatives to promote active learning. These strategies

included curricular working groups, faculty professional development workshops,

research on learning initiatives, and online learning communities (Macdonald &

Manduca, 2002;Libarkin & Kurdziel, 2002;Manduca et al., 2010; Kastens & Manduca,

2012; Budd, Kraft, McConnell, & Vislova, 2013). Despite this investment and some

evidence of success (Macdonald et al, 2005; Budd et al., 2013), widespread adoption of

active learning teaching strategies has not been achieved.

　　The study compared and contrasted the influence of two faculty development

strategies initiated in the field of geoscience. The study investigated how departmental

context influences participants' adoption of teaching approaches promoted by the

programs. This information was used to test a theory of change that could potentially be

used to inform future evaluations of faculty professional development programs in STEM

fields. The theory of change was drawn from situated learning theory (Cobb & Bowers,

1999; Adler, 2000; Putnam & Borko, 2000). Situated learning theory provides a means

for interpreting how faculty learn about teaching. It examines faculty learning through the

multiple inter-connected social opportunities in which faculty engage. For example, it

connects what is learned by a faculty member at a professional development opportunity

to the subsequent colleague-to-colleague interactions related to teaching. The theory

examines participant context as a part of understanding the learning process.

　　In the higher education studies related to context, the term culture is mainly used,

even in cases where the term climate may be more accurate. The intent of this study was

to gain an understanding of faculty members' perceptions of the norms, values, and practices related to teaching in their department. The term climate as understood in the literature is the more accurate term for this study. However, scholars of situated learning theory predominantly use the terms "context" or "physical and social context." These scholars define context as the act of participating in social practices. Cobb and Bowers (1999) note that with this conceptualization of context, "all individual actions are viewed as elements of an encompassing system of social practices and individuals are viewed as participating in social practices even when they act in physical isolation from others" (p. 5). This paper uses the term" culture" within the literature review to reflect the particular scholars' views and language. However, when referring to aspects of the study for this paper, the term "context" is used to be consistent with situated learning theorists.

I hypothesized that the way that a faculty member perceives his or her departmental and institutional context mediates and moderates his or her collegial interactions related to teaching and in turn to his or her teaching practices. Therefore, the study examined how faculty teaching practice is influenced by the perceived context of his or her department and institution and by the attitudes and practices prevalent in his or her disciplinary community. Existing studies which make use of situated learning theory have focused on K-12 teacher training and the K-12 context. To interpret the higher education context within the umbrella of situated learning theory, this study made use of the theoretical framework of Tierney (1988) related to institutional culture in higher education. In this way the study aimed to improve understanding of the role of context in faculty learning and the intersection of these influences on changes in teaching practices.

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The study rested on the hypothesis that faculty learning encompasses both the act of participating in the faculty development opportunity and subsequently how faculty reflect upon and discuss their teaching practices with other colleagues. Scholars claim that access to supportive resources (which could include social relations) is critical to adoption of new teaching practices (Adler, 2000; Cobb & Bowers, 1999; Lave & Wegner, 1991). Following a faculty development experience, participants return to their department. The degree to which they perceive their department as a supportive resource could be critical to their adoption of the new active learning practices. In departments where multiple disciplines may have distinct and disparate perceptions about teaching, finding support to make changes in teaching practices may be more difficult. Participants may need to seek teaching networks outside of their departments. Conversely, the greater diversity in disciplines and types of research could also provide a context where teaching practice is viewed as the common bridge across colleagues. The study investigated the strategies perceived by faculty as important in mediating departmental differences related to active learning teaching and fostering productive collegial interactions related to this type of teaching.

This study addressed the primary research question:

1. What factors related to departmental context do participants of faculty development programs perceive as influencing their ability to adopt active-learning pedagogy in the STEM disciplines of geoscience?

Significance of the Study

This study is significant in three respects. First, it contributes to knowledge regarding faculty professional development programs. Recent published evaluation studies of faculty professional development programs have focused on participant satisfaction or on participants' reported or observed teaching practice (Hilborn, 2012; Ebert-May, 2015). Evaluations have not provided insight into why programs aimed to promote active learning teaching practices have had inconsistent and disappointing results. In addition, few evaluations of such programs have investigated faculty learning and practice in relation to departmental or institutional context. This study informs how evaluations of such programs could consider context in terms of data collection, methods, and conclusions drawn about program effectiveness. Second, geoscience departments are at a critical juncture in determining whether to pursue a credentialing or competency-based path for their curricular programs (Arthur et al., 2007;Bralower et al., 2008; Moses, 2014). The study examined how disciplinary differences among faculty in geoscience departments may influence teaching practices. Finally, this study contributes to the literature related to STEM professional development. This study focused on strategies aimed at professional development for early career faculty. Other STEM disciplines are also investing in strategies specific to faculty early in their careers (Krane, 2012; Pfund et al., 2009). In addition, this study focused on strategies aimed at professional development activities delivered to an entire department. This strategy is of particular interest to higher education organizations (e.g., the AACU Institute on Integrative learning and the Departments or the AAU Bay View alliance of STEM research departments). By

examining strategies aimed at these two target audiences, the study highlights contextual factors that can inform the improvement of similar initiatives undertaken in the broader STEM education community.

Definition of Key Terms

Active learning pedagogies: Scholars refer to a set of pedagogies in the literature as evidence-based teaching, scientific teaching, or active learning pedagogies. Some of these pedagogies have explicit protocols (e.g., Student-Centered Activities for Large Enrollment Undergraduate Pedagogies, SCALE-UP). More frequently, scholars refer to a broad set of teaching strategies that include small group discussion; think,pair,share approaches; group problem-solving; personal response system methods; or peer instruction strategies. (Freeman et al., 2014; Macdonald, Manduca, Mogk & Tewksbury, 2005; Handelsman et al., 2004). This paper refers to the broad set of these strategies.

Culture: Scholars in higher education often use culture interchangeably with context and climate. In the literature, culture is defined as the "collective, mutually shaping patterns of behavior" within an organization and the "norms, values, practices, beliefs and assumptions" of its members (Kuh & Whitt, 1988, p. 12). Culture is associated to a specific organizational context. The term *culture* will be used in this paper when referencing the corresponding literature in higher education.

Climate: In organization learning literature, climate refers to a description of the current perceptions and attitudes by individual members about the practices and patterns of behavior within the organization (Peterson & Spencer, 1990).

Context: Scholars of situated learning theory in education define context as the act of participating in social practices. Cobb and Bowers (1999) note that with this conceptualization of context, "all individual actions are viewed as elements of an encompassing system of social practices and individuals are viewed as participating in social practices even when they act in physical isolation from others" (p. 5). This paper will use the term *context* to be consistent with the scholars of situated learning theory.

Chapter 2: Literature Review

The overall purpose of the study was to examine factors related to departmental context that support the use of active learning pedagogy by participants of faculty development programs, specifically in the STEM disciplines related to the study of geoscience. Despite considerable expenditures on faculty professional development programs, the adoption of active learning pedagogy in STEM disciplines has been disappointing, suggesting the need for studies to investigate the causes of poor adoption. The geoscience disciplines offer a promising area to study these issues. They have been the focus of numerous active-learning initiatives but have also suffered uneven adoption rates (Macdonald et al, 2005; Budd et al., 2013). There is no consensus as to the reasons for program failure. Existing evaluations have focused on participant satisfaction and adoption of specific pedagogies. These evaluation studies fail to shed light on what factors inhibit adoption. Studies of K-12 teacher development have used the situated learning theory to explicate how context influences teachers' ability to learn about and make changes in their teaching practice (Borko, 2004; Putnam & Borko, 2000; Adler, 2000). A few studies in STEM have examined the influence of context (institutional, departmental, and disciplinary) and identified ways that context supports or inhibits such change (Kezar, 2011; Kezar & Eckel, 2002; Fairweather, 2005, Henderson & Dancy, 2007). This suggests the need for a study that investigates the influence of context on the adoption of active learning practices. The study yields insight into the reasons for program failure and success.

This chapter is organized into four sections. The first section reviews literature related to the program or change theories used by faculty professional development. The second section reviews the literature related to faculty cultures, specifically how disciplinary, institutional, and departmental culture influence teaching practices. The third section provides a description of situated learning theory. One model from the higher education literature is presented as a means of interpreting factors related to higher education context. The final section provides a description of the context of the study. This review of literature largely focuses on what is known about faculty development and teaching in the disciplines which make up the study of geoscience. Within this final section, the chapter describes two specific faculty development programs that were the focus of the study.

Faculty Development Program and Change Theories

When examining social or organizational change, change theories can reveal the driving forces behind change, how change will occur, and what type of outcomes will occur (Kezar, 2011). Making explicit these assumptions about how programs are expected to influence change is useful in guiding evaluations and understanding why programs fail or succeed (Rogers & Williams, 2005). Different evaluation approaches, such as program theory evaluation (PTE) or Realistic Evaluation, rely on change theories as part of the practice. Scholars have studied the underlying program theory or change theory for faculty development programs in order to understand which program theories show greater evidence of success.

Henderson, Beach, and Finkelstein (2011) reviewed studies regarding strategies used to promote change in instructional practices. Their review of 191 journal articles encompassed STEM education research, faculty development, and higher education research. The review identifies four change strategies. The first strategy involves disseminating curriculum and pedagogy for use in science courses. For those articles where adequate data was presented, the evidence of effectiveness was weak. These studies demonstrate that often faculty require more support and feedback in order to adopt new curriculum and pedagogy (Ebert-May et al., 2011; Penberthy & Millar, 2002). Moreover, participants in these studies had limited influence in disseminating the curriculum beyond their own classroom (Skelton, 2004; Davidovitch & Soen, 2006). The second strategy involves interventions to develop reflective teachers. Studies suggest moderate evidence of effectiveness. In these studies, teacher beliefs about learning are strong predictors of change in teaching practice (Weiss, Feldman, & Capobianco, 2004; Gess-Newsome, Southerland, Johnston, & Woodbury, 2003; Kember & Kwan, 2000). This predictor is also present in the sample of curriculum and pedagogy dissemination studies which demonstrated effectiveness (Gibbs & Coffey, 2004; Ho, Watkins, & Kelly, 2001). The third strategy involves the implementation of policies that are meant to influence teaching practices. However, evidence of success is uneven. In general, top-down policy is less successful than policy change strategies that adapt to campus culture (Colbeck, 2002; Browne, 2005). The fourth strategy involves interventions intended to foster a shared vision within a department. The shared vision aims to support new teaching approaches. This strategy demonstrates promise but few studies are available.

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In a literature review commissioned by the National Science Foundation, Kezar (2011) asserts that the research model of innovation diffusion (Rogers, 1995) advocated by NSF solicitations is not an adequate model for curriculum reform. The innovation diffusion model assumes that an innovation which has been effectively used in one setting can be broadly disseminated and used in a wide range of settings. Kezar identifies two failures of this model. First, the model assumes that those faculty situated in a broad range of settings have an interest in the given innovation. Second, the innovation is always viewed as "new" and fails to become the norm. Kezar points to lessons learned from the international community development literature and the K-12 literature. She identifies three critical features for a successful change strategy. First, the change initiative needs to include deliberation and discussion about the innovation among colleagues. Second, the initiative must connect change agents with others attempting the same change efforts. Last, there should be sufficient rewards and incentives to promote widespread adoption.

Fairweather (2008) also asserts that until professional development is rewarded and incentivized by department chairs, it will not be viewed as a mainstream practice by faculty in their work. In a paper commissioned for the National Research Council, Fairweather critiques the assumption that empirical evidence is a sufficient condition to enable widespread adoption. He argues that studies already demonstrate the benefit of these reform efforts (Fairweather & Beach, 2002; Kuh, Kinzie, Schuh, & Whitt, 2005; Eiseman & Fairweather, 1996). Teaching, he states, is "at odds with the research process" even for faculty who are deeply committed to their teaching (Leslie, 2002; Eagan et al.,

2014;Massy, Wilger, & Colbeck, 1994). In a previous national study, Fairweather (2005) found that the more time faculty spent on classroom teaching, the lower their average salary. He argues that faculty members respond to the reward structures in which they work. For this reason they will use teaching strategies that optimize the time available in order to allow for research time. Change strategies, he asserts, should focus less on identifying the most effective pedagogies and more on widespread adoption of any pedagogy that is known to improve student learning. He recommends interventions that connect faculty members who are invested in curricular reform across institutions. Finally, Fairweather argues that evaluation of reform efforts should focus on investigating the process of adoption rather than understanding which pedagogies work.

Several studies and reviews of faculty development programs suggest that it may not be the underlying program theory, but rather that some programs were poorly implemented. The implementation problems across programs are varied. Sustained faculty development activities are more successful than one-time workshops (Garet, Porter, Desimone, Birman, & Yoon, 2001; Loucks-Horsley, Stiles, Mundry, & Love, 2003; Fishman, Marx, Best & Tal, 2003). Yet, faculty attrition frequently undermines program effectiveness (NRC, 2011b; Clark, et al., 2004; Silverthorn, et al., 2006). In some programs, additional training is necessary because faculty lack familiarity with the particular content. In programs that advocate an apprenticeship model, courses are team taught with a faculty member paired with a curriculum expert. But institutions often lack the resources necessary to fund a curriculum expert for all course offerings. Still other programs only attract faculty already skilled in curricular reform. These programs show

negligible effects because the faculty participants are already operating at a high level. Finally, some faculty development programs promote a curriculum which has only been field tested with students who possessed high levels of academic preparation. Faculty participants who taught heterogeneous student populations could not achieve the same results (Silverthorn, et al., 2006; Clark, et al., 2004).

Faculty Cultures

In addition to examining change and program theories, higher education scholars also investigate the academic communities of faculty in order to develop understandings about behavior, practice, and decision making in higher education. Faculty members identify with different communities in their professional lives. These communities include their institutional culture, their departmental culture, and their disciplinary culture. Each of these communities may have a set of shared norms, behaviors, and values that influence the faculty teaching practices. The disciplinary culture is viewed as central to shaping faculty identity (Kuh & Whitt; 1988; Chesler & Young, 2007; Austin, 1990). In combination with the departmental culture, the disciplinary culture influences how faculty view and interact with colleagues (Knight & Trowler, 2000). Disciplinary culture shapes research, determines practices related to publication and authorship, and defines the characteristics of effective teaching (Austin, 1990; Stark, 2000). The department serves as an organizational element within the institution. The department may include faculty from a single discipline or multiple fields of discipline. As an organizational element, the department interprets and enacts aspects of institutional culture. Institutional culture identifies the mission and governance of the organization.

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Institutional culture determines curricular structures, identifies procedures for faculty recruitment and socialization, and sets faculty performance standards and student-to-faculty ratios. These elements can all influence how faculty members think about the practice of teaching.

Influence of Disciplinary Context on Active Learning Teaching Strategies

The discipline-specific challenges that learners face in undergraduate STEM classrooms inspired specific active learning teaching strategies. These disciplinary challenges fall into three areas. First, students' misconceptions about critical topics can limit their development of specialized knowledge and skills. Specific teaching strategies have been developed to address these misconceptions. Second, instructional strategies have been designed to address deficits in students' abilities in areas which are deemed critical for success within a given field. These areas include skills such as problem solving, dealing with uncertainty, spatial thinking, or making and testing hypotheses. Finally, the setting for conducting research in the discipline influences teaching strategies notably in laboratory, studio, and field settings.

Undergraduate course descriptions frequently identify required prerequisite knowledge for a given course. Indeed, program tracks and course goals are written with the aim of advancing students who possess little or no prior knowledge to more expert-levels of knowledge and skills. Yet it is the incorrect understandings that students take as commonsense which limit their ability to succeed in their chosen fields (Chi, 2005, 2008; Chi, Feltovich, & Glaser, 1981, Chinn & Brewer, 1993; Schoenfeld, 1992). Research in the sciences has identified many of these common and deeply rooted misconceptions. For

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example, students may believe that denser objects fall more rapidly than lighter objects in a vacuum. Students hold this misconception because they may have observed a denser object, such as a walnut, fall more rapidly than a lighter object, such as a leaf. Research related to these misconceptions has shaped teaching strategies and assessments to measure the efficacy of the strategies.

The field of physics (Hestenes, Wells, & Swackhamer, 1992;diSessa, 1982), chemistry (Barke, Hazari, &Yitbarek, 2009; Talanquer, 2002; Mulford & Robinson, 2002), engineering (Reed-Rhods & Imbrie,2008), astronomy (Bailey & Slater, 2005), biology (D'Avanzo, 2008; Anderson, Sensibaugh, Osgood, & Mitchell, 2011), and geoscience (McNeal, Miller, & Herbert, 2008; Libarkin, 2008; Piburn, Kraft, & Pacheco, 2011) have each identified student disciplinary misconceptions. Based upon these studies, cognitive researchers developed, tested, and validated concept inventory instruments that measure changes in students' learning related to the concepts where mistaken beliefs commonly occur. In physics, hundreds of studies of student learning and teaching strategies have relied on the physics forced concept inventory, which is an assessment survey that requires the student to select between the correct concept and a common sense alternative (Hestenes, Wells, & Swackhamer; Hestenes & Halloun, 1995; Huffman & Heller, 1995).

Several promising teaching practices have emerged to address disciplinary misconceptions. The "bridging analogies" strategy uses a series of analogies to link from students' common misconception to the correct understanding. Moderate evidence of learning gains supports the use of this approach when teaching physics to students

(Clement, 1993; Sokoloff & Thornton, 1997) and a few studies suggest that it may also

be effective when teaching biology and geoscience (D'Avanzo, 2008; Jee et al., 2010;

Tolly & Richmond, 2003;Truscott, Boyle, Burkill, Libarkin, & Lonsdale, 2006).

Collaborative teaching strategies combined with rapid formative assessment, known as

concept tests, also show strong evidence of learning gains in physics, chemistry, biology,

and geoscience (Sokoloff & Thornton, 2004; Bowens & Phelps, 1997; McConnell, Steer,

& Owens, 2003). With these teaching strategies, students in a lecture-setting are asked to

reflect on a concept presented either in narrative or as a demonstration. The students

discuss the concept, make predictions related to it with fellow students, and respond to

questions by the instructor. The instructor can assess students understanding to the

questions either by a show of hands or through "clicker" technology which provide

immediate assessment of the frequency of correct responses.

Particular deficits in skills deemed critical to the discipline provide another area

where teaching strategies have been tested for efficacy. Three such examples are Process-

Oriented Guided Inquiry Learning (POGIL)(Bunce, Havanki, & VandenPlas, 2008),

Student-Centered Active Learning Environment for Undergraduate Programs (SCALE-

UP), and the Just-in-Time Teaching or Learn Before Lecture strategies. The POGIL

teaching strategy arose from the field of chemistry (Lewis & Lewis, 2005; Tien, Roth &

Kampmeier, 2002). This teaching approach addresses students' deficits in critical

thinking and problem solving. With this technique, faculty facilitate guided inquiry

activities with students working in small groups. First, the students explore a model

which leads to an introduction of a specific concept. This is followed by an activity that

requires students, working in their groups, to apply the concept. Faculty observe and when needed help to facilitate student learning. SCALE-UP is a teaching strategy that also uses cooperative group learning. This strategy intends to improve students' problem solving and students' ability to make and test conjectures. SCALE-UP has demonstrated moderate evidence for improving problem solving abilities in physics and more limited evidence in engineering, chemistry, and mathematics (Gaffney, Richards, Kustusch, Ding, & Beichner, 2008; Beichner et al., 2007). SCALE-UP requires classrooms designed with specific requirements, such as round tables of specified diameters and technology accessible at each table. These classrooms require significant investment by the institution. According to a National Research Council report (2012), nearly 100 institutions (two percent of the estimated 4,400 two and four year institutions) had constructed these specially designed classrooms by 2011. The Just-in-Time Teaching or Learn Before Lecture strategy is designed to improve critical thinking and problem solving for students enrolled in large introductory courses in biology, geoscience, and physics (Marrs & Novak, 2004; Linneman & Plake, 2006; Luo, 2008; Formica, Easley, & Spraker, 2010). This strategy shows evidence of increasing students' conceptual knowledge as well as positively influencing student attitudes about science. Students are given lecture materials (powerpoints, videos, or notes) and a brief online quiz prior to the class session. The class session is structured around small group problem solving activities and formative assessment questions. This strategy is similar to the "flipped classroom" strategy from the K-12 setting.

Certain teaching approaches have been developed for field settings or laboratories. The empirical evidence for these methods is more limited (NRC, 2012). In geoscience (Mogk & Goodwin, 2012) teaching strategies have been explored that give students experience learning in the field during the limited time allowed for laboratory science coursework. With these strategies, geoscience faculty use the time allowed during transportation to the field location as a means of instructing students in background information. The background activity is designed to engage students in organizing their field notebooks. In the field, faculty give students short activities which scaffold the data collection process and guide field observation studies. Faculty use the return travel time to assess student learning and answer questions related to the field experience. Evidence suggests that these field experiences have the potential to improve students' conceptual understandings and increase students' interest in geoscience related careers (Huntoon, Bluth, & Kennedy, 2001; Elkins & Elkins, 2007). Teaching strategies designed for laboratory settings have been used in biology, chemistry, and physics courses. These teaching approaches encourage students to replicate the practices of science research (i.e. developing hypothesis, collecting data, making decisions about data and measurement, and reporting findings). Through these strategies, faculty encourage students to use inductive reasoning (Domin, 1999) and to confront students' misconceptions through experimental design (Johnson & Lawson, 1998). Evidence suggests that these laboratory approaches increase students' abilities to understand and replicate experimental designs and recognize the process of science in research (Karelina & Etkina, 2007; Shaffer et al., 2010).

Influence of Institutional Culture on Teaching Strategies

Studies and commentaries that relate institutional culture to teaching often focus on the ways that institutional culture inhibits changes in teaching. Characteristics of institutional culture such as the allocation of workload, the determination of promotion and tenure metrics, and inaccessibility of resources can restrict faculty motivation and limit changes in teaching (Lawrenz, Huffman, & Appeldoorn, 2005;Fairweather, 2008; Kezar, 2011). Institutions, however, can also induce such change.

In a review of faculty development activities, Stabile and Ritchie (2013) describe three levels of support that postsecondary institutions provide related to teaching. First, accreditation requirements may obligate institutions to focus on teaching. With such a mandate motivating change, only low-levels of compliance by faculty are typically visible. In these cases, institutions provide minimal professional development in order to satisfy the requirement, such as inviting a one-time speaker. Faculty attendance at such events is typically used as a measure of success.

The second level of support that Stabile and Ritchie (2013) describe is a more comprehensive faculty development program. With this level of support, postsecondary teaching institutions identify a particular gap in student learning and commit resources, materials, and personnel to foster improvement. Campus initiatives related to quantitative reasoning, writing across the curriculum, or service learning are examples of these types of initiatives. The approaches to these initiatives vary from brown bag seminars to department or campus-wide lectures (Rutz, et al., 2012). Evidence of success for these initiatives is often descriptive rather than empirical (Conger et al., 2010; Perkins, 2011;

Verni & Nicols-Grinenko, 2014; Chalah, Hwang, & Habbal, 2014). For faculty

development initiatives that relate to student writing, moderate evidence of success is

demonstrated through higher ratings of student writing portfolios (Grawe, 2011; Haswell,

2001; McLeod et al., 2001). Institutions may offer extrinsic reinforcement for faculty

participation through stipends. Stipends, however, may be insufficient to motivate

change. Studies suggest that faculty beliefs influence their willingness to adopt a change

in their teaching practices. In this way, faculty who believe that improvement is

necessary or feel a duty as a leader are more likely to adopt new practices (Stabile &

Ritchie, 2013; Willett et al., 2014).

Faculty enrichment programs are a third level of support provided by institutions.

Enrichment activities offer faculty opportunities to reflect on his or her teaching practice.

Stabile and Ritchie identify a "faculty educator" as a central role in this type of support.

The faculty educator designs activities where faculty participants engage in methods that

allow them to try new methods and discover what works in their teaching. These

activities can include co-teaching, modeling new methods, or holding structured

community discourse. In a controlled study of enrichment level training at 22 universities

in 8 countries, Gibbs and Coffey (2004) identified strong evidence of success in changes

to teaching practice which correlated with student learning gains. They attributed the

success to multiple methods of training, ongoing forms of support, and including reward

and promotion as part of the initiative interventions.

Two approaches used by institutions for creating enrichment levels of support are

faculty learning communities and learning and teaching centers. Faculty learning

communities (FLC) are small groups of faculty (typically 8 to 12 faculty members). The FLC can be cross-disciplinary or disciplinary specific. The groups engage in active, collaborative discussions about enhanced teaching and learning. In a survey of 132 institutions with established FLCs, 72% of the institutions reported course redesigns as a frequent outcome of faculty participation in FLCs (Richlin & Cox, 2004). At Miami University (Cox, 2004), the FLCs were an outgrowth of student learning communities, a cohort model of undergraduate instruction. Miami University envisioned FLCs as a means of building faculty interest in undergraduate teaching and learning, nourishing scholarship related to it, and increasing the prestige of teaching. In addition to positive responses by faculty, Miami University showed some evidence for the intervention's impact on student learning. In an analysis of 50 FLC course portfolios, 74% to 92% (depending on the type of student learning) were viewed as stronger in student learning measures (Cox, 2004). At Iowa State University, FLCs include 80 faculty across science departments. The goal of these FLCs is to change large-enrollment introductory labs from "cookbook" practices to use more active teaching techniques. The FLCs allow faculty to learn about practices and reflect on what works best within disciplines (Ogilvie & Henderson, 2014).

Learning and teaching centers are another way for institutions to influence faculty teaching practices. These centers may be across all disciplines or be situated as STEM centers on a campus. The University of Colorado offers one promising STEM center example. The Science Education Initiative Center at Colorado seeks to transform teaching across seven of its science departments at the institution. The center works with

department action teams to develop shared vision and reflective teaching activities to foster changes in teaching practice (Reinholz et al., 2014). After four years of the center's intervention, they reported evidence of change with over 60% of faculty in three of the science departments. These faculty members made changes to adopt more active teaching strategies. Additionally, faculty in these courses demonstrated greater learning gains for students using pre and post-test measures compared to students in comparative courses where more traditional teaching approaches are used (Wieman, 2009). Program leaders attribute the department-based science education specialists acting as "faculty educators" as essential to the success of the program.

Influence of Departmental Culture on Teaching Strategies

While a considerable body of literature describes the influence of institutional culture on faculty, less is understood about the role of the departmental culture. Austin (1990) defines the department as the basic organizational element in all American colleges and universities. Yet she views the discipline as the major cultural force in the professional lives of faculty. She describes "invisible colleges" of colleagues connected by specific disciplines (p. 63). These collegial networks influence faculty members' values and professional activities. In a comprehensive study of institutional culture by Kuh and Whitt (1988), they identify discipline and academic life as two subcultures within an institution. They fail to include the department as its own subculture. Clark (1984) describes the departmental culture as the convergence of the institutional culture and the disciplinary culture.

In a study of departmental culture using national survey data, Lee (2007) argues since academic departments provide the organizing structure across all colleges and universities, a stronger understanding of the influence of departments on teaching is needed. Clark (1984) reasoned that because of the complex connections between institutional culture and disciplinary culture, departmental culture has been largely uninvestigated. In an analysis of 1988 survey data from Higher Education Research Institute (HERI), Lee examines the relative influence of institutional culture and disciplinary culture on faculty responses to variables within departmental units. The HERI survey is administered to faculty at over 1,100 institutions (Eagan et al., 2014). It is intended to provide institutions with a comprehensive understanding about key aspects of faculty life. Lee used individual departments as the unit of analysis in all regressions. She identified 13 dependent variables as related to culture (e.g., collegiality, commitment to diversity, or valuing professional autonomy).Overall, Lee found that while differences in responses by discipline exist, these differences affect departmental culture to a lesser degree than the differences between institutions. One notable exception rests with the two variables related to teaching (commitment to students' affective development and commitment to teaching). With these variables, Lee found that the institution and the discipline contributed relatively similarly toward the departmental cultures.

A few additional studies examine the influence of departmental culture on teaching. In an interview study of 300 faculty at 20 colleges and universities, Massy, Wilger, and Colbeck (1994) investigated the role of departmental context on teaching. They identified patterns of behavior in departments where the majority of faculty were

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more engaged in improving teaching. These patterns included frequent interaction among faculty, high tolerance and appreciation for differences (in theory and methods), equity and respect across service lengths, commitment to workload equity across the department including regular course rotation, frequent evaluation of teaching (both peer and student-driven), a consensus process for decision-making, balanced incentives for teaching and research, and strong leadership. They referred to these patterns as "authentic collegiality." In contrast, the majority of the departments they studied had behaviors which furthered civility, equity, and allowed faculty to maximize discretionary time. This type of collegiality, however, did not lead to substantive focus on improving teaching practice and a sense of collective responsibility was absent. They referred to this behavior as "hollowed" collegiality because of its superficial nature. They include a set of recommendations for those in departmental leadership roles who seek to shift to a culture focused on improving teaching. These include a focus on continuous improvement, evaluation, teamwork, communication, and a shared commitment to quality undergraduate education. Site studies of 21 thriving undergraduate physics programs underscored the same themes related to departmental culture. These include a strong sense of community, a disposition toward continuous evaluation, and sustained leadership and teamwork (Hilborn & Howes, 2003).

Knight and Trowler (2000) draw on international studies of faculty work environments and their own qualitative study of early career faculty in the U.S. to understand departmental context. They argue that "improving teaching involves developing systems of work relations, most significantly at the departmental level" (p

69). Knight and Trowler attribute a loss of collegiality as a critical problem that negatively influences faculty teaching practice. They identify three ways that this loss of collegiality manifests itself. First, faculty no longer have time to socialize because of increased workloads. Second, they note that many faculty no longer work at the physical site of his or her institution and that this remote work behavior limits collegiality. Finally, they place blame on the development of a managerial culture at institutions which they believe limits collegiality. Managerial culture, they argue, prevents authentic opportunities of interaction. Rather than discussing teaching, departmental interactions focus more on management practices related to tasks such as budgets or hiring procedures. Like the earlier qualitative study, Knight and Trowler argue for more reflective and responsive departmental leadership. They suggest that leaders foster opportunities for collaboration and provide embedded opportunities for mentoring and faculty development. They contend that leadership need to make such opportunities an integral part of faculty members' professional learning.

Situated Learning Theory

Recent evaluation studies of faculty development programs have measured participant satisfaction or collected data about participants' teaching as measures of understanding program success or failure (Hilborn, 2012; Ebert-May et al., 2015; Smith et al., 2014). Few evaluations have examined how the prevailing social context of the participants influences program outcomes. Individual faculty identify with different social units such as their disciplinary community, their institution, and their department. The situated learning theory provides a framework for connecting what is learned by a

faculty member at a professional development opportunity to the subsequent colleague-to-colleague interactions related to teaching. It examines the role of participant context as a part of understanding the learning process.

Situated learning theory arises from research in cognitive psychology, sociology, and anthropology (Lave & Wenger, 1991; Putnam & Borko, 2000; Jarvis & Parker, 2005; Dall' Alba, 2004). Learning is conceptualized as both 1) the use of knowledge by an individual as a result of participating in social activities pertaining to practice in a specific domain (such as science teaching) and 2) the collective changes in participation in the socially organized activity itself. Evaluation studies of faculty development have focused solely on the former aspect. Evaluation methods and measurements have centered on what knowledge, skills, and attitudes the individual participants of programs have acquired and put into practice. With the situated learning perspective, such evaluations would also examine how different participant's contexts connect to a larger system or community of practices.

Putnam and Borko (2000) suggest that in order for evaluation of professional development to use a situated learning perspective, the evaluation approaches must consider multiple perspectives and make use of multiple units of analysis. This approach, they argue, provides a more broadly constructed view. For example, the evaluator would examine participation patterns of the collective community based on different demographics (e.g., faculty from different types of institutions or faculty from different sizes of departments). In addition, the evaluator would gather data which characterizes the context of the individual participants. Data could include course load or numbers of

enrolled students. It could also include qualitative data related to the norms and practices within the participant's context. Putnam and Borko refer to this aspect of context as "discourse communities." Discourse communities, they argue, enculturate members into ways of thinking about teaching and learning. Both units of analysis (group and individual) and both perspectives (participation and context), researchers contend are critical in the use of a situated learning theory. To examine why multiple perspectives and multiple units of measurement are viewed by researchers as essential, the underlying assumptions of situated learning theory are explored.

Assumption one: Learning is Situated

Situated learning theorists argue that learning cannot be seen as independent of the physical and social contexts in which the learning transpires. Theorists suggest that how a faculty member learns a particular set of pedagogical knowledge or skills and the situation in which the faculty member learns all become a fundamental part of what is actually learned. While a traditional cognitive theory perspective would focus on the individual as the unit for measurement and analysis, a situated learning theory shifts the perspective to consider an interactive system that include the participant's context (Lave & Wenger, 1991; Cobb & Bowers, 1999).

In the field of cognitive psychology there is debate between the traditional view of cognition where learning is independent of context and this situated learning perspective which includes context as part of the study of learning (Anderson, Reder, & Simon, 1997; Greeno, 1997). Through experimental designs, cognitive theorists have tested to what extent, if any, specific aspects of the social context seem to correlate with

learning for individuals. Situated learning theorists argue that determining whether the unit of measure is at the individual level or the social collective is an artificial distinction. Because the actual learning about teaching is only realized in the classroom over an extended period of time, they argue that the analyses must consider the social interactions and context that support or inhibits such learning (Cobb & Bowers, 1999; Putnam & Borko, 2000; Boud & Walker 1998).

Assumption 2: Learning is Social in Nature

Grounded in the premise of Vygotsky (Russian text cited by Putnam & Borko, 2000, p. 5) that learning is essentially a sociocultural activity, researchers, dissatisfied with learning studies which focus on the individual, have come to recognize the role of others in the learning process. Their constructivist perspective describes a community of learners who share a common interest. With this theory, learning is conceptualized as being inherent in the discourse and practices of that learning community (Putnam & Borko, 2000; Resnick, 1991; Lave & Wenger, 1991). In this way, the acquisition of knowledge and skills result from group interactions over a period of time. With this perspective, the evaluator of professional development programs examines participants' interactions with their community of colleagues. Moreover, educational researchers suggest that learning is not one-directional but that the community changes through the new ways of thinking that each participant brings to this discourse (Putnam & Borko, 2000; Schoenfeld, 1992).

Participation in professional development using this lens is viewed by researchers as continuous learning. With this approach the evaluator would not be limited to

evaluating only the planned activities but would also investigate how learning by participants is informed by the everyday discussions with colleagues and students. Because socialization can legitimize certain knowledge and in turn shape the professional identity of the faculty participant, Webster-Wright (2009) argues that it is imperative for the evaluator to examine the social context, in order to avoid accepting implicitly the power structures of the organization (p. 723).

Survey and interview studies show variation in the ways that faculty of different disciplines use discourse to inform their teaching (Lueddeke, 2003; Stark, 2000; Beyer, Taylor, & Gillmore, 2013). These studies illustrate the ways that faculty rely on colleagues as trusted sources. These studies suggest that one strategy for disseminating faculty learning is through colleague-to-colleague interactions. In the natural sciences, Stark (2000) found that the academic discipline of the faculty participant provided the strongest influence on course planning. Stark interpreted that for faculty, his or her discipline is inexorably linked to beliefs about the purpose of education. This suggests that discourse serves as a way of norming teaching behavior for faculty and works as a means of inculcating others in the professional practice.

Assumption 3: Learning is Distributed

Researchers in the field of organizational learning have conceptualized the idea of learning as distributed (Kasl, Marsick, & Dechant, 1997; Brooks, 1994). Rather than measuring learning within an organization at the individual level, scholars in the business fields study the workings of teams and how teams learn. These scholars examine how learning is distributed across teams in order to make teams capable of tasks beyond what

is possible by the collection of individuals (Kasl et al.,1997). This suggests that research into the situated, social, distributed nature of workplace learning could provide an understanding for new ways to evaluate faculty professional development.

Faculty knowledge about teaching has a number of ways of moving beyond the specific faculty learner. Webster-Wright (2009) suggests that practicing professionals, which includes teaching professionals, learn from such a diverse range of formal professional development programs and other more incidental and routine activities. She posits that this learning is shaped from and through the interactions with colleagues and students in different combinations of experiences. The departmental reviews, hallway conversations, and repurposing of research colleagues into teaching and learning colleagues can all contribute to the individual's learning and the collective learning. In this way, she argues that professional development could influence changes in behavior beyond the individual participant to other members of the department or disciplinary community.

Scholars suggest that learning across an organization may be influenced by all the experiences of its collective members (Webster-Wright, 2009; Kasl et al., 1997). Qualitative studies have linked the professional identity of a faculty member to his or her teaching practice. This identity is shaped by perceptions related to time in the classroom, reactions to past training, and the type of feedback received from colleagues or students. These studies reveal that faculty are often influenced by their recollections for how they best learned as students. They integrate these recollected approaches into their practice. These studies speculate that each faculty member brings his or her suite of experiences to

interactions with colleagues and thus can influence colleagues' learning as teachers (Beijaard, Meijer,& Verloop, 2004; Oleson & Hora, 2013).

The situated learning theory exposes the dynamic and messy nature of studying learning where multiple spheres of influence are present. It is useful as an interpretive framework in considering faculty learning as "an act of participation in a system of practices that are themselves evolving" (Cobb & Bowers, 1999, p. 8). This theory may illuminate other influences which can catalyze or inhibit learning. What is missing are constructs for investigating the structures and norms related to the higher education context of a given participant. In higher education scholars have suggested that these structures can vary by institution as well as within an institution. Faculty may be involved in multiple, changing social units (Bergquist, 1992; Tierney, 1997; Fox, 2000; Boud & Middleton, 2003).

Studying Higher Education Culture

Whereas the situated learning theory suggests that the evaluation of faculty learning should include an examination of the broader context, the theory fails to provide a framework for understanding higher educational contexts. William Bergquist (1992) describes how the use of evaluation within an organization context can focus on how to improve current structures and processes. For this type of evaluation, Bergquist asserts that a different approach is needed. The approach should investigate to what extent an organization has capacity to take on work that is significantly different in nature from the current norms. Bergquist refers to this type of change as second order change. A considerable body of literature exists related to studies of second order change. This

literature provides theoretical frames for examining organizations (Bolman & Deal, 1997;

Birnbaum, 1988). Organization leaders use these frameworks to better inform change

initiatives. Their investigations offer case studies within the scholarly business and

human resource development literature (Peters & Waterman, 1982; Kotter, 1982). This

body of work informs models which have also been applied to the study of colleges and

universities. One scholar in higher education to provide such a model is William Tierney.

Tierney (1988) argues that a conceptual framework is needed to understand

culture in higher education institutions. While it may be simple to name and describe the

external forces that institutions face such as economic pressures, changes in

demographics, or policy implications, Tierney asserts that a conceptual model should also

account for the history, beliefs, and meanings that are shared by an institutional

community. Understanding culture, he argues is essential in discerning distinctions

between institutions that seem similar on paper. The knowledge gained about cultural

variances can be used by leaders to solve institutional-scale problems. Members within

the community may carry an implicit understanding of the internal layer of forces. When

something new is initiated that does not fit or runs against unwritten codes at the

institution, then members gain greater awareness of their institutional culture. Making

cultural models more explicit, Tierney argues, would give institutions a proactive stance

toward change and an understanding of what may inhibit such change.

Six concepts are proposed by Tierney (1988) to fit within his framework of

organizational culture: environment, mission, socialization, information, strategy, and

leadership (p.8). The perceived value and attitudes that members have toward the

regional home of their institution, such as a population-dense urban center, defines the environment of the institution. How mission is articulated, defined, and used is another concept in the framework. Tierney describes mission in terms of members' current understandings as well as how mission was understood historically. Departments within an institution may articulate and enact this mission in unique ways. He uses socialization as a concept to describe how new members are inculcated. It is during socialization that members realize what they need to know or do in order to excel and survive in the particular institutional or departmental culture. Socialization helps faculty members learn how teaching, research, and service are valued and measured at their institution and by their department. The fourth concept of the framework is information. What information channels are used, for which constituencies, and how information is visible and enacted across the institution and within the department are studied. Strategy is the fifth concept. It characterizes how decisions are made, who makes these decisions, and how decisions are judged. Leadership is the final concept in his framework. It characterizes the types of leaders and expectations placed upon them by their institution and their colleagues. Studies of departmental culture have identified leadership as a critical component to improved teaching within a given department (Knight & Trowler 2000; Massy, Wilger, & Colbeck; 1994).

These six concepts for the cultural framework emerged from a yearlong ethnographic case study Tierney conducted at one specific institution. While a single institutional case study may not seem to be enough for the basis of an enduring framework, the extended body of work built upon this study suggests that the framework

still holds value. Not only has Tierney continued to build upon these concepts in his own studies (Rhoads & Tierney, 1990; Tierney & Foster, 1991; Tierney, 1997) but the Web of Science lists his original article for the framework as cited in 105 other peer-reviewed publications with half of these citations occurring in the last five years.

Applying this Theory and Framework to Program Theory

Applying the situated learning to a program theory for a faculty professional development initiative may allow the evaluation to investigate how faculty learning is inhibited or supported by his or her departmental context. It allows the evaluation to consider the role discourse with peers in influencing changes in teaching. In addition, the evaluation could examine whether the ensuing discussions about teaching, in turn, influence colleagues who were not participants of the program. Within the situated learning umbrella, the six concepts introduced by Tierney (1988) may shed additional light on the program theory. The evaluation could use these concepts to illuminate what aspects of institutional and departmental culture appear to influence the participant's ability to make changes in teaching. The concepts could suggest ways that the cultural context supports or constrains collegial interactions related to teaching.

Context for Study

Studies of STEM faculty reveal variation in the ways that faculty of different disciplines use discourse to inform their teaching (Lueddeke, 2003; Stark, 2000;Beyer, Taylor, & Gillmore, 2013). In departments where faculty come from multiple disciplines, each may express different philosophies toward teaching. Sharing teaching ideas with colleagues of differing viewpoints could bring new perspective to teaching and curricular

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approaches. Conversely, the differences could introduce tensions, particularly where colleagues share course workloads. The purpose of the study was to investigate the factors that support the use of active learning teaching strategies by faculty in the disciplines related to geoscience. The field of geoscience was selected for this study for several reasons. First, the field of geoscience encompasses a varied set of disciplines (e.g., geology, geophysics, meteorology, oceanography, limnology, geochemistry, biogeochemistry, climate science, environmental science, environmental and geological engineering, planetary science, and physical geography). Because there exists "no central canon of knowledge" for geoscience, the content and programs vary by institution (NRC, 2012, p. 49). The teaching and curricular approaches to these programs reflect the multiple disciplines which are represented within the given institution. In addition, the geoscience curriculum appears at a critical point in its development and evolution. Departments have struggled to balance curricular approaches that arise from the traditional fields of geology with those that come from new pressing challenges related to climate change, sustainability, and water and energy resource constraints.

Responding to national studies which called for changes in teaching (NSB, 1986; Boyer, 1990; NRC, 1996), the geoscience disciplines have been the focus of numerous interventions to promote active learning teaching. These initiatives arose from a national meeting where geoscience leaders documented their shared vision for undergraduate education across the varied disciplines (Ireton, Manduca, & Mogk, 1997). At that time, the academic culture related to geoscience was fragmented and highly discipline-oriented. Professional societies related to geoscience were focused on supporting the

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research culture (Macdonald et al., 1996). As part of the new vision, leaders advocated for faculty development initiatives to promote active learning teaching strategies and interdisciplinary curricula approaches.

Over the last twenty years, a range of strategies for professional development have been pursued, providing an opportunity to compare and contrast the influence of these strategies. National surveys reveal that participants of interventions were more likely to report active learning strategies than nonparticipants (Macdonald et al, 2005; McLaughlin et al., 2010). Despite moderate evidence of success, widespread adoption of active learning teaching strategies has not been achieved.

Motivated in part by the disappointing uptake in active learning teaching, a second national meeting, sponsored by the National Science Foundation was held in 2014. The purpose of the meeting was to develop a new collective vision for the future of geoscience education (Mosher et al., 2014). New scientific approaches in the geoscience disciplines require students to learn to work across disciplinary boundaries. Leaders expressed a greater urgency for changes in teaching and curriculum in order to address the serious challenges related to climate change and sustainability. Leaders identified two priorities for motivating a greater diffusion of teaching practices. First, department chairs were identified as a critical support in establishing and rewarding a teaching culture. Leaders asserted the need for faculty development initiatives to include departmental leadership. Second, they affirmed the need for professional development for early career faculty (Mosher et al., 2014) as a means of ensuring qualified teaching in the professorate.

Influence of Disciplines on Geoscience Teaching

The field of geoscience appears at crossroads. Departments face competing demands in balancing curricular approaches related to the traditional fields of geology with those that come from fields related to climate science. In a recent committee report by the American Geoscience institute (AGI, 2014), three paths were discussed for external validation of curricular programs. These included accreditation, classification, or competency-based paths. A coalition of geology professional associations (American Association of Petroleum Geologists, American Institute of Professional Geologists, and Association of Environmental & Engineering Geologists) advocate for accreditation for the bachelor degree programs (Arthur et al., 2007). Proponents view accreditation as a means of ensuring a common knowledge base and keeping standards for curriculum content. In response, geoscience faculty members from other disciplines argue that accreditation would stifle the ability of departments to address climate change and sustainability through curriculum (Bralower et al., 2008; Moses, 2014).

The education tracks of the four largest professional societies related to geoscience reveals a community interest in teaching and curriculum strategies related to climate change (American Geophysical Union, 2014; American Meteorological Society, 2014; Association for the Sciences of Limnology and Oceanography, 2014; Geological Society of America, 2014)., Topical searches across the last four years of journal articles (2010 to 2014) for the Journal of Geoscience Education (peer-reviewed journal for geoscience education research, curriculum, and teaching) reveals a similar pattern. Over

the same time period there were fewer education articles related to core subjects within traditional geology curriculum (Drummond & Markin; 2008).

The core geology subjects that are included on state licensure exams may dictate how curricular is taught in traditional geology programs. A study of geology state licensure exam results (National Association of State Boards of Geology) from 1992 to 2003 showed a trend toward higher failure rates (Williams, Warner, & Warner, 2004). While the researchers suggest multiple factors (e.g., lack of quantitative preparation and student motivation) for the failure rates, they claim that changes in teaching and curriculum were a contributing cause. The researchers suggest that while new courses and curriculum may be more attractive to students, the overall requirements of the major were becoming less rigorous. The researchers acknowledge that this claim was based mostly on anecdotal evidence. The researchers also note that the reduction in the number of semester units for a major may also have contributed to the failure rates.

Why some Geoscience Disciplines may have Difficulty Adopting More Active Learning Pedagogies and Others Seek Teaching Improvements?

Studies indicate that teacher beliefs about learning are strong predictors of changes in teaching practice (Gess-Newsome et al.,2003; Kember & Kwan, 2000). Teacher beliefs are influenced by a range of factors including a faculty member's prior experiences as a learner, their ongoing experience in the classroom, and the socialization from their disciplinary community they receive as graduate students and early career faculty members (Oleson & Hora, 2013). Geology faculty may embrace more traditional teaching methods in order to safeguard content which they view as critical to gaining

professional licensure. In addition, geology faculty advocate for standardized curriculum in order to ensure a consistent path for graduates who plan to enter traditional geology careers (Arthur et al., 2007). Moreover, some departments have strong industry connections with oil, gas, and mining industries, organizations which have called for accreditation. These relationships may be long standing. Maintaining these connections provides an important way of ensuring the placement of graduates in competitive career paths. When a disciplinary community views changes in teaching as fundamentally detrimental to their discipline, it may be difficult for a professional development initiative to motivate change.

Issues related to climate science such as climate change, extreme weather, sea level rise, water scarcity, and energy consumption have become part of the public's consciousness. Increasingly, funding agencies have focused on supporting research, outreach, and education related to these issues (Bralower, Feiss, & Manduca, 2008). Faculty in climate science may perceive a heightened responsibility toward educating the future citizenry on these issues. They may also have opportunities for recognition and funding for these efforts. For a change initiative to be successful, faculty need to have an interest in the given innovation and sufficient rewards and incentives (Kezar, 2011; Fairweather, 2005). In climate science, the interest and rewards may help drive teaching and curricular changes. Moreover, if climate science faculty view their teaching about these issues as complimentary rather than at odds with their research (Fairweather, 2008), it may provide further incentive to engage in faculty development initiatives to improve their teaching.

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Two Geoscience Faculty Development Programs

The study drew upon participants from two different faculty development programs for geoscience faculty who teach undergraduates: the On the Cutting Edge Professional Development program and the Building Strong Geoscience Departments program.

The On the Cutting Edge Professional Development Program for Geoscience Faculty (CE) (Macdonald, Manduca, Mogk, & Tewksbury, 2005) is a 13 year NSF-funded program for geoscience faculty that focuses on changing teaching practice to more active learning and evidence-based teaching. Its ultimate goal aims to improve student learning. The full set of program activities includes topical workshops, virtual events and communities, and collections of web resources (Macdonald & Manduca, 2014). This study focused on the Early Career aspect of this program. The Early Career program includes a four day face-to-face workshop, an optional visit to the National Science Foundation, virtual topical webinars, a community email list, and a website of resources. Through the workshop activities, faculty participants gain knowledge and practice in active learning and assessment strategies. They discuss strategies for balancing teaching, research, service, and life and they develop a support network of other early career faculty. Participants are typically in the first or second year in a faculty position (Macdonald et al., 2012). Comparable programs are offered for early career faculty in other disciplines (biology, physics, chemistry, and engineering) (Hilborn, 2012).

The evaluation of the CE program used end of workshop surveys to gauge participants' reaction to events and follow up surveys and interviews to understand how participants attributed changes in teaching to the program (McLaughlin et al., 2010). Over the course of the program evaluation, evaluation capacity was developed so that every event routinely measured participants' satisfaction. In addition, a cohort of faculty were trained to conduct structured observations of samples of participants' teaching. While national surveys identify differences between how participants and nonparticipants describe teaching strategies, less is understood about the factors that motivate and support teaching changes (Macdonald et al., 2005).

The Building Strong Geoscience Departments program (Departments) was an NSF-funded project from 2004 to 2013. It aimed to stimulate discussions and disseminate community expertise on approaches to curriculum and teaching as well as recruiting faculty and students. It included community visioning activities (e.g., surveys, town hall meetings) focused on identifying the characteristics of thriving departments (Rossbacher & Rhodes, 2004; Richardson & Ormand, 2008). The program included workshops, professional society meeting sessions, and a collection of website resources. It offered three types of workshops: national topical workshops, an annual one-day workshop for department heads and chairs, and a traveling workshop (beginning in 2009). The traveling workshop program sent workshop leaders to the site of a participating department. Faculty members from an entire department participate in an onsite workshop that lasts 1.5 to 2 days. Workshop programs were customized to the needs of the department but included topics such as curricular needs assessment, curriculum

design and transforming teaching practices, student recruitment, workforce preparation, and program assessment. The traveling workshop program has now become part of the National Association of Geoscience Teachers (NAGT) professional development offerings.

Like the Cutting Edge program, the evaluation of the Departments program used end of workshop surveys and follow up surveys to assess participant's reaction and potential influences on participant and participant's department. In addition, the external evaluator conducted case studies with seven departments. Of particular relevance to this study, one of the case studies highlighted a split in teaching philosophy between faculty members from traditional geology and faculty from hydrogeology, soil science, and climate science (Lee, 2010).

Both the Early Career workshop and the Traveling workshop aim to situate the program design in a faculty context. The Early Career workshop employs a "whole faculty" approach to its program. It includes information and resources relevant to multiple aspects of the professional lives of faculty including: teaching, research, and service. The program situates learning about teaching with the other aspects of faculty life. In this way, it reflects how faculty must balance competing priorities when they return to their institution. The Traveling workshop aims to situate its program within the institutional context of the department. It drives faculty to consider their curricular goals in alignment with institutional mission and goals. The Traveling workshop leaders hypothesize that the department has a greater chance of succeeding in their changes as a group when situating department actions within institutional goals.

These programs aim to improve undergraduate instruction and consider faculty context as part of their program design. Each program employs different strategies. The Early Career workshop focuses on change at the individual faculty level. The Traveling workshop focuses on change at the departmental level. The study compared and contrasted these two approaches. It examined how faculty perceived program influence and which strategies appeared to have the stronger effect.

Involvement of researcher in programs of study. I have been involved with the internal evaluation for both of these programs. For the Cutting Edge program, I collaborated with the external evaluator on a theory of change, end of workshop survey items, interview studies, and national surveys. In addition, I attended and observed the 2005 Early Career workshop where I developed a reflection instrument to gauge participant's perceptions of knowledge and skills gained related to teaching and research plans. For the Departments program, I collaborated with the external evaluator on end of workshop survey items, and follow up surveys. In addition, I conducted on-site interviews with faculty, students, and administrators for one of the department sites.

Chapter 3: Methodology

Methodological Approach and Research Question

This study used a mixed-method case study methodology to investigate the influences of department context on faculty members' adoption of active-learning teaching practices. The study compared and contrasted the influence of two faculty development strategies initiated in the field of geoscience. A case study approach was selected for this study because this approach is suited for investigating phenomena where an understanding of contextual conditions appears relevant and where local meanings are important (Yin, 2009; Stake, 1994).

Chapter 1 detailed a need for a better understanding of the reasons for program failure and success in STEM faculty professional development programs. Few existing evaluations have considered the context surrounding faculty members (specifically, the departmental, institutional, and disciplinary influences) and its role on teaching. There is a need for evaluations that investigate how the context surrounding each faculty member shapes his or her ideas about teaching. This type of evaluation may shed light on factors that contribute to successful faculty development programs. Therefore, the following question guided this study:

> What factors related to departmental context do participants of faculty
> development programs perceive as influencing their ability to adopt active-
> learning pedagogy in the STEM disciplines of geoscience?

Research Design

Six university geoscience departments were selected that had participated in two national geoscience professional development programs: 1) On the Cutting Edge Professional Development Program for Geoscience Faculty (Cutting Edge), specifically participants from the Early Career Workshops, and 2) Building Strong Geoscience Departments Traveling Workshops (Traveling workshops) program. The purposeful sampling of university departments was implemented using a group characteristics sampling frame (Patton, 2014). Departments were selected that varied according to key factors (highest degree granted by department, disciplines represented within department, size and composition of department, and tenure status of interview subjects). Two departments were selected from those that participated in the Traveling workshop program, but had no members who participated in the Early Career workshop. Two departments were selected from those that had no involvement in the Traveling workshop program, but where multiple department members had participated in the Early Career workshop. Two departments were selected that participated in the Traveling workshop program and had multiple Early Career workshop participants (see Table 3.1).

Table 3.1

Case selection from two faculty development programs

Department	Traveling workshop participants	Early Career participants	Number of interview subjects
1	Yes	Yes	3
2	Yes	Yes	3
3	Yes	No	3
4	Yes	No	4
5	No	Yes	3
6	No	Yes	3
Total: 6 Departments			19 faculty interviews

Three faculty members were selected as subjects from each department (with the exception of one department, where four faculty members were selected). For one case, two faculty participants expressed such antithetical perspectives related to organizational context, that a fourth participant was added to the study in order to seek a broader understanding of that situation. The multiple participants from each department allowed the investigator to examine how different faculty members perceived a common experience. Because the study focused on perceptions related to active learning pedagogy, the study was limited to faculty members who had taught undergraduate courses within the last year.

Figure 3.1

Research Design
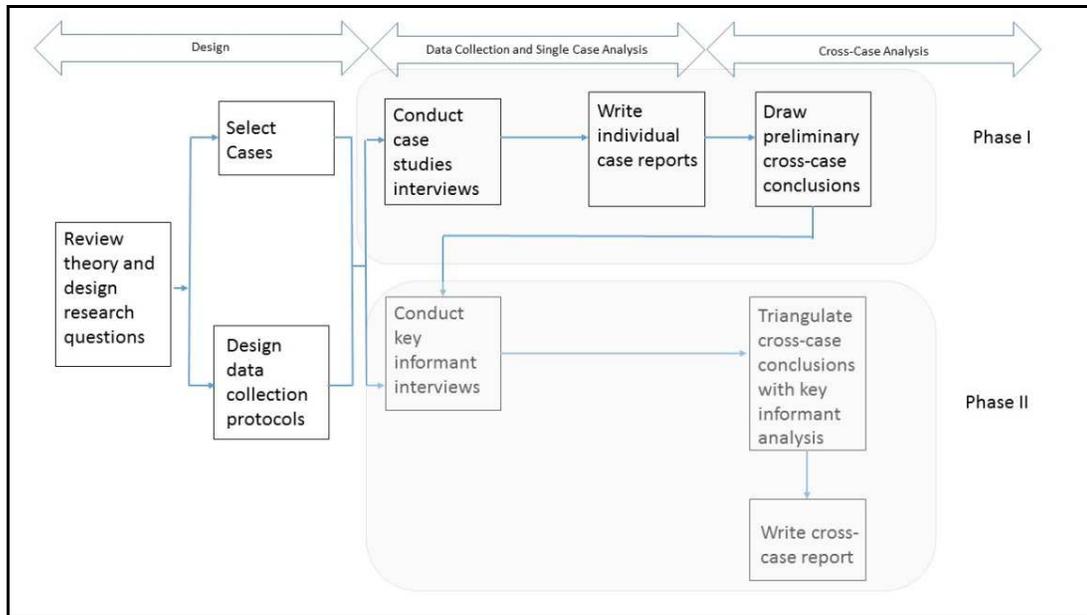
Case Selection

This study investigated factors related to departmental context that were perceived by faculty as influencing their ability to adopt active learning teaching, specifically in the STEM fields related to geoscience. Department case selection was designed to compare and contrast the two professional development strategies and the factors related to departmental context that participants of those programs perceived as influencing their ability to adopt active learning teaching. There was some overlap between the two programs. When queried, a leader of the Traveling workshop program who is also a leader for the Early Career workshop indicated that there are around a dozen departments in the Traveling workshop program that included participants of the Early Career workshop (H. MacDonald, personal communication, July 17, 2015). Two cases were

sought for this overlap. This allowed the study to investigate how participants of both programs perceived departmental influences (see Table 3.1).

Cases were sought where a diversity of disciplines existed within the department. Faculty members of geoscience departments come from a variety of disciplines, including geology, geophysics, atmospheric science, oceanography, and climate science. As described in Chapter 2, a possible distinction related to curricular approaches appears between faculty who belong to the traditional field of geology and faculty who study climate change (Bralower et al., 2008).

The proposed study was confined to departments that offer a four year, geoscience-related degree. The two-year college structures and norms related to work allocation, promotion and tenure, and types of courses are sufficiently different from those departments offering four year degrees (Macdonald, Baer, Blodgett, Hodder, & McDaris, 2014). In addition, the Cutting Edge program as a whole did not attract many participants from two-year colleges. Cases were sought to capture a range of departments based on the highest degree offered by the department. As described in Chapter 2, different institutional contexts can influence teaching practices (Wright et al., 2004, Austin, 1996; Tierney, 1997).

Finally, departments were selected that included faculty at different stages of their professional careers (see Table 3.2). As noted in Chapter 2, whether a faculty member is tenured can have an influence on how he or she prioritizes his/her teaching (Fairweather, 2008; Fairweather, 2005). When known (McDonald et al., 2012), the demographics of

total participants for the program for each dimension of interest guided the sampling.

Written consent was obtained from all subjects.

Table 3.2

Description of faculty interviews by department site

Department	Highest Degree	Position	Discipline	Years Teaching	Traveling	Early Career
Marble	B.S.	Professor	volcanology	18	Yes	
Marble	B.S.	Professor	water & climate	11	Yes	
Marble	B.S.	Professor	tectonics	25	Yes	
Marble	B.S.	Associate	geomorphology	11	Yes	
Copper	B.S.	Assistant	tectonics	3		Yes
Copper	B.S.	Associate	geophysics	8		Yes
Copper	B.S.	Associate	geochemistry	8		Yes
Jasper	M.S.	Professor	water & climate	9	Yes	Yes
Jasper	M.S.	Professor	meteorology	27	Yes	
Jasper	M.S.	Professor	meteorology	26	Yes	
Gabbro	M.S.	Professor	geomorphology	24	Yes	
Gabbro	M.S.	Assistant	tectonics	3		Yes
Gabbro	M.S.	Professor	volcanology	19	Yes	
Olivine	Ph.D.	Associate	geophysics	12		Yes
Olivine	Ph.D.	Associate	water & climate	11		Yes
Olivine	Ph.D.	Associate	tectonics	5		Yes
Granite	Ph.D.	Professor	geochemistry	35	Yes	
Granite	Ph.D.	Assistant	tectonics	4	Yes	
Granite	Ph.D.	Professor	environmental geology	20	Yes	

Key Informant Case Selection

The key informant interviews were selected from the set of Principal Investigators

(PI) as well as facilitators from each of the workshop programs. Initial contact was made

with all project key informants prior to the case selection process. The participating key

informants included PIs and facilitating leaders from each program. These faculty

represented a range of institution types and department sizes (see Table 3.3). The sample

included faculty who had past experiences as institutional administrators, officers of

national professional organizations, and as an NSF program director. In addition, one

leader in the geoscience education community was selected who had no direct

involvement in either Early Career or the Building Strong Geoscience Departments

traveling program. This informant was selected based on high visibility and national

recognition as a leader in the geoscience education community (using grant metrics and

leadership of other national community efforts). The list of possible subjects was

reviewed by two of the program PIs. In this way, the leaders were aware that preliminary

findings were to be shared. Written consent was sought from all key informants prior to

participation.

Table 3.3

Description of Key Informant Interviews

Faculty pseudonym	Position	Years teaching	Department size	Highest degree granted by department
Howlite	Professor	38	29	Ph.D.
Garnet	Professor	19	6	B.S.
Agate	Professor	33	7	B.S.
Beryl	Professor	38	25	Ph.D.
Peridot	Assistant	6	11	M.S.

Data Collection Protocols and Procedures

Qualitative Study

Interviews were conducted with each informant. Each interview subject was

invited to participate via an email. The email described the purpose of the study,

indicated the awareness of the leaders with the study, a brief description of the interview

data being requested, and time requested for the interview (see appendix for sample

emails). From each department, five to fifteen faculty members were selected based on the sampling criteria from each selected department and the size of the selected department. Emails were sent to an initial set of four faculty members from the given department. Each faculty member was given up to one week to respond to the interview request before moving on to the next participant of the dimensions of interest (same discipline, institution type, workshop participation history) within the same department. If no faculty agreed to participate from the initial seven faculty who were emailed for that department, another department was selected based on the same dimensions of interest (type of faculty development program and institution type). See Table 3.4 for a description of the responses for departmental cases and faculty interviews. The same invitation process was repeated. Once a faculty member agreed to participate, additional details about scheduling and the participation consent form for the study were emailed to the participant.

Table 3.4

Response rate for interviews by department and by faculty

Sample type based on faculty development program	Response rate by department	Response rate by faculty
Traveling only	2 of 7	7 of 44 (16%)
Early Career only	2 of 2	6 of 8 (75%)
Overlap†	2 of 2	6 of 15 (40%)

†Department participated in traveling program and had at least one member who participated in an Early Career workshop.

All interviews were conducted by telephone in January and February of 2016. The interview protocol was submitted as part of the application to the University of Minnesota's Institutional Review Board (IRB) in December of 2015. Signed consent was

received electronically from all interview subjects prior to the start of the interview. At the beginning of each interview, the interview participant was reminded about the informed consent prior to recording the interview. Once any questions by the subject were answered, the recorder was turned on. The interviews lasted between 35 and 70 minutes. At the 35-minute mark of the interview, the researcher asked whether the faculty member had additional time to continue the interview. The researcher used a semi-structured interview approach. All primary questions were asked verbatim. As described on the protocol, wait time and prompts were used to encourage response and to manage pacing. The researcher took high level, handwritten notes during the interview. These notes served to identify key timing points that highlighted particular responses, to distinguish any deviations in the order of questions, to note any affect in response, and to make note of particular terminology to flag for transcribers.

Following the interview, the researcher typed a one-page description of initial interview impressions. Each of the recordings was subsequently transcribed verbatim. The digital recorder segmented the audio into thirty-minute sectors. The first thirty minutes of all interviews were transcribed by an outside transcription service that guaranteed confidentiality and security of the data. The remaining second segment was either transcribed by the researcher or by the outside service depending on the length of the interview. A list of content-specific vocabulary was provided to the service to ensure quality. The researcher quality checked all transcription files against the actual recording and made minor corrections as needed. The transcription files were kept on a secure

server with identification numbers. The case identification number mapped to the full name of the faculty participant was kept on a separate folder of the secure server.

An artifact study was included as part of the study. Data were collected about each departmental case in order to situate the given department within an institutional context and compare the department sites. The data included: institutional information, including number of faculty, numbers of students (undergraduate and graduate students), history narrative, current mission statement, and, if available, strategic plan; departmental information, including number of tenure-track positions, highest degree granted, types of program degrees offered, number of majors, number of graduate students, departmental vision and mission statement, and any data pertinent to their participation in the faculty development program (see appendix for list of artifacts by site). The researcher used institution and department websites to collect information that was publicly available. For two of the sites, a department member sent the researcher other documents not available from the website.

A database was maintained that included the chain of evidence for each case. It mapped each electronic file by case number. The mapping included the digital audio file names, transcribed audio file names, department data artifacts file names, filenames for any transcribed interview notes, and documentation by date of all electronic communications.

Key Informant Interviews

Like the faculty, key informants were invited to participate via an email. The email described the purpose of the study, indicated the awareness of the PIs (for the two

non-PI subjects), and time requested for the interview (see appendix for sample email).

Once a key informant consented to participate in the study and written consent was

obtained, the subjects was emailed a brief summary report of preliminary findings and

scheduling information.

All interviews were conducted by telephone. At the beginning of the interview,

the research plan and summary findings were briefly described. Once any questions by

the participant about the research were answered, the recorder was turned on. Following

the interview, the recording was transcribed. The interview protocol for the key

informants focused on collecting other interpretations to the findings. These

interpretations were based on their experiences as geoscience faculty and from a history

with STEM faculty development initiatives. The digital audio file, transcribed audio file,

any interview notes, and PDFs of electronic communications were organized in a

database on a secure server.

Phase I Analysis

For each department case, the researcher assembled the interview notes,

transcribed audio, and department and institution data artifacts. A summary site record

was written for each case. The site record summarized the participants' responses to

interview questions. This description also summarized the set of data related to the

department and institution. Pseudonyms were used for faculty names and institution

names. Initial observations were included comparing the departmental and institutional

data artifact to what faculty reported in the interview related to the departmental culture.

This method aligned with case study methodology in that it allowed the researcher "to

identify and describe before trying to analyze and theorize" (Chadderton & Torrance, 2011).

Subsequently, the researcher used an iterative process to build an understanding of the patterns that emerged from each case and across cases. First, the researcher read each site description and then read the full transcript and sets of notes from each interview in order to identify initial patterns or codes. The conceptual framework (see Figure 3.2) and the stated research question were used as a guide for understanding potential patterns. For example, the researcher analyzed the transcript and notes, looking for responsive patterns related to the six institutional concepts (environment, mission, socialization, information, strategy, and leadership) introduced by Tierney (1988). Each of these concepts was used an initial code. Other initial codes included faculty description of teaching and characterizations of faculty development. These codes were entered into the software package NVivo (version 10). All of the transcripts and notes were imported into this program. The researcher analyzed the transcribed qualitative interviews using a pattern matching strategy related to the initial set of codes. Using a process of constant comparative analysis (Glaser & Strauss, 1967), the codes that were identified during the exploratory analysis were examined in the available data (interview transcript and interview notes). The researcher intentionally used larger "buckets" for these codes rather than attempting to identify more subtle themes at the start. This approach allowed the researcher to conduct multiple iterations. Through this iterative process, additional patterns emerged from the data and additional codes and sub-codes were used. The software package NVivo was used throughout the coding process. This software package

allowed the researcher to identify the embedded units of analysis (such as patterns specific to institution type or departmental composition).

A cross-case matrix was developed based on an iterative pattern analysis across all of the sites. Queries in NVivo assisted in identifying prominent patterns across cases. First, the researcher imported a case classification matrix. The case classification matrix identified by interview subject the dimensions of interest such as site, faculty development experience, years of teaching, discipline, or highest degree granted by department. These dimensions were mapped to each source. The classification aided in queries across different units of analysis. For example, from the six written site records, "teaching introductory courses to large enrollments" emerged as an explanatory element related to how faculty perceived pedagogy. Through iterative analysis of the verbatim transcripts, the researcher identified different facets of this explanatory element. These items were added to the cross-case matrix. Through iterative queries and pattern matching, the researcher identified how each site perceived these facets as an influencing factor toward improvements in teaching (positively, negatively, neutral, or no response related to this facet from any of the site data). The cross-case matrix was also employed to help the researcher identify rival explanations. Rival explanations emerged from within a site analysis where interview subjects had different understandings for "the way things are." Rival explanations also emerged across cases when departments employed similar structures or strategies but described their perceptions differently. These rival explanations served to refine the cross-case matrix.

The final analysis step of this phase was to examine the department and institution artifacts in aggregate. After an exploratory review of all of the artifacts, the researcher used the set of codes that emerged from the interview analysis to triangulate the evidence related to these codes. The characterization of the department and institution by the interview subjects was triangulated with the coding from these artifacts and included in the revisions of the site records. Using this triangulation and the cross-case analysis, the case site records were iteratively revised. A preliminary draft describing the cross-cutting themes across all of the sources of evidence was written.

Figure 3.2:

Conceptual framework
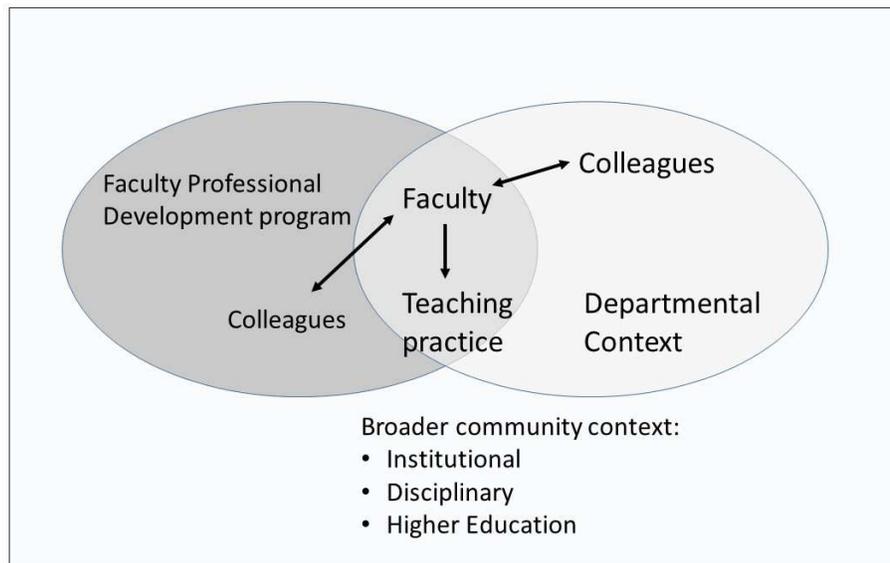
Phase II Analysis

The second phase of the analysis focused on integrating what was learned from the key informant interviews with the case studies. First, the researcher analyzed the transcribed interviews from the key informants. Like the case study analysis, the

researcher began by an exploratory read of each transcript. From this reading, the researcher identified initial patterns. The primary purpose of this analysis was to identify patterns of agreement and disagreement among the key informants. This analysis also compared the preliminary findings with key informant interpretations. Where there appeared to be agreement with specific patterns, the researcher made notes about the nature of the agreement, from what types of sources, and identify any illustrative quotations. For disagreement, a similar analysis procedure followed. These disagreement patterns were organized into codes to identify where a rival explanation may be supported. The researcher used these codes to conduct another analysis of the case studies. This final analysis highlighted interpretive differences and areas of agreement. The cross-site findings and discussion were revised accordingly.

Dealing with Potential Threats to Validity

Maxwell (1996) describes several potential threats to validity associated with research that involves qualitative methods: description, interpretation, theory, researcher bias, and reactivity.

This study used audio recordings of interviews, full transcripts of these audio recordings, and documentation via electronic communication to ensure completeness of all evidence collected. A database was organized for each case study that linked to all lines of evidence (e.g., audio recording, interview notes, electronic communications, and transcribed interview, department and institution data artifacts, case study report, additional reports or information obtained from websites or participant). A separate file

was maintained with any identifying information. This file was kept on a separate part of the secured server. The database also kept records of all analysis files.

The study employed triangulation of multiple sources of evidence in the analysis to limit threats to validity from interpretation and researcher bias. The key informant interviews provided a means of community member checking. As described in the analysis section of this chapter, triangulation was employed in both phase I and phase II. In phase I, the multiple sources of evidence (interview transcripts, and departmental and institution data artifacts) were used to formulate interpretations. In phase II, the key informant interviews were used to confirm interpretations or to inform rival explanations for the themes from the case studies.

The qualitative analysis was grounded in the conceptual framework (see Figure 3.2) that emerged from existing theory. The framework situated faculty in both the context of the given professional development opportunity and his or her departmental context. The case study design allowed for the investigation of influences related to faculty learning about teaching in multiple settings. The study examined how participants of faculty development perceive his or her departmental context as an influence to adopting active learning teaching strategies. The study interpreted faculty learning as social and situated in the context of the faculty member. Therefore, the study examined how faculty perceive the social interactions with colleagues related to teaching influences on his or her practice. From these perceptions the researcher examined how learning about teaching was situated within the broader context of disciplines and institutions.

The researcher employed a process that was open to examining patterns for rival explanations to minimize threats based on theory. As described, the key informant interviews provided a basis for identifying such rival explanations. In addition, all protocols were reviewed by a peer evaluator and an informant knowledgeable in the geoscience education community prior to conducting interviews in order to minimize the effect of the researcher.

Limitations of the Study

The study consisted of six case studies carried out with qualitative methods. There are several limitations of the study. These limitations relate to the sample size, the selection criteria, self-report nature of the data, and the potential bias of the single investigator.

First, the study focused on a small sample. It involved interviews with 19 faculty at 6 geoscience departments. The faculty interviewed for each department represented a fraction of the faculty in the department. Each case was constructed from the perceptions of the faculty interviewed. The study sought to understand the different experiences and perspectives of these faculty to characterize how departmental context influences faculty adoption of teaching practices. The study was intended to be exploratory research rather than a comprehensive study of all faculty experiences. Moreover, there are approximately 900 geoscience departments including an estimated 7,000 faculty in the U.S. (American Geophysical Institute, 2015). The study could not expect to portray the full range of faculty perspectives.

Second, the study included departments and faculty based on their participation in two geoscience faculty development programs. The selection criteria limited the findings to the perspectives of faculty who had demonstrated some interest in improving their teaching through participation in faculty development. The study was also limited to faculty who taught undergraduate courses. In some departments faculty teach only graduate courses or hold research-only appointments. The viewpoints of these types of faculty are absent from the study. Geoscience faculty who have no involvement in geoscience faculty development or who do not regularly instruct undergraduates may have different motivations or barriers related to their teaching practices. These viewpoints are not investigated in the study.

Third, the study used two different self-report methods for gathering data. In-depth interviews from a small set of faculty were the primary collection methods. Data gathered were based upon these subjects' viewpoints. The study also compared their data with external key informant perspectives and institutional and departmental documents. However, the design of this study did not use direct observation of faculty or departmental interactions. Therefore, the data are subject to the bias of these interview subjects.

Finally, the study was carried out by one researcher. The researcher had been an internal evaluator for both of the faculty development programs. In addition, the researcher has been involved in geoscience education initiatives for over ten years. The researcher's experience with geoscience and STEM education initiatives brought deeper knowledge to the study. However, such knowledge could introduce potential bias. The

researcher relied on triangulating data from verbatim transcripts and multiple data

sources. In addition, the researcher cross-checked findings with key informants and

published studies to address any limitations related to potential bias.

Chapter 4: Site Case Descriptions

Six departments were selected that had participated in at least one of two national geoscience professional development programs: 1) On the Cutting Edge Professional Development Program for Geoscience Faculty (Cutting Edge), specifically participants from the Early Career Workshops and 2) Building Strong Geoscience Departments Traveling workshops (Traveling workshops) program. Two departments had sent 6 faculty to the Early Career workshop. Two departments had sent multiple faculty to Early Career workshops and had hosted a Traveling workshop. Two departments had hosted a Traveling workshop only.

An iterative process was used to identify themes related to faculty perceptions regarding the influence of departmental context on the adoption of active learning strategies. Where appropriate, the site descriptions employ headings that are common across multiple sites.

Throughout the chapters of this paper, pseudonyms are used for the names of institutions and faculty. The settings for these cases are geographically dispersed across the country. The campuses are located in metropolitan areas and rural locations. They are situated near oceans, mountains, and cornfields. Limited information about the specific geographic location of each campus is given. This decision was made to protect the anonymity of the faculty who participated in this study.

The site case descriptions are presented in order of the highest degree offered by the given department. The bachelors granting departments are presented first, followed by masters granting, and finally doctoral granting departments.

Geoscience Department at Greater Marble State University

The geoscience department at Greater Marble State University hosted a Traveling workshop program in 2011. In the fifteen years prior to the workshop, enrollment at the institution doubled in size. However, the infrastructure at the institution had not kept pace with enrollment. To meet the needs of the increased enrollment, the department doubled from 6 to 12 tenure track faculty. During that time the diversity of the disciplines the faculty represented increased. The career and graduate paths of the students transitioned from traditional mining and oil trajectories to environmental fields. In addition, the department collaborated with other science departments to develop an integrated science program degree for pre-service elementary teachers. Despite all of the changes, the department curriculum developed in the early 1960s remained the same. Some of the faculty in the department perceived the Traveling workshop program as a step toward bringing in new ideas about curriculum and teaching. The faculty who requested the workshop viewed curriculum reform as a means to better align faculty strengths to student needs.

In this department 4 faculty were interviewed who had participated in the Traveling workshop. The 2 faculty who were first scheduled for interviews expressed widely contradictory perspectives about the department context. For this reason the researcher added a fourth interview subject for this site. The faculty interviewed

represented fields from both "hard rock" (2 faculty) and "soft rock" (2 faculty) disciplines. Their fields include geomorphology, paleo-climate and environmental geology, hydrology, tectonics, and volcanology. There appointments include full professorships (3 faculty) and an associate professorship. Their years of teaching ranging from 11 to 25 years.

Institutional Background

Greater Marble State University is a regional campus situated on the edge of a small city of 20,000 residents and serves approximately 25,000 students, of which nearly 22,000 are undergraduates and 3,000 are graduate students. More than 90% of the undergraduate population come from within the state and most (82%) identify themselves as white. Over 40% of the students are identified as the first generation in their family to attend college. Nearly two-thirds of the students rely on financial aid. The campus was established fifty years ago as a regional four year college by the state legislature. The state legislature envisioned the college serving the "baby boomer" generation of students in the region. Its mission identifies teaching, scholarship, and public service as critical aspects of the university's contributions.

Over the last twenty years, the campus has nearly doubled in enrollment. Nevertheless, the college retains its liberal arts philosophy towards education that was envisioned by its founding leaders. The institution prides itself on having all undergraduate courses taught by faculty, rather than graduate assistants. Several years ago, a new science building was constructed for life and health sciences. The geology department remained in the existing science building at the center of a sprawling campus.

Its Carnegie classification is Master's Colleges & Universities: Larger Programs. It offers two doctoral degrees in health services fields and offers 36 Master's Degree programs.

Departmental Background

The department has four full, six associate and two assistant professors. It offers three emphasis for a Bachelor of Science degree. The B.S. program has three potential emphases in the fields of geology, geology/geochemistry, or earth science for secondary education. In support of these different education programs, faculty have specialties in geochemistry, geophysics, hydrology, paleoclimate, volcanology, petrology, and structural geology/tectonics. Not quite half of the faculty in the department (5 of 12) have participated in national geoscience faculty development workshops (in addition to the Traveling workshop). A few faculty have shared appointments in teacher education. In addition, one faculty member shares an appointment in the Honors College. The department takes pride in the undergraduate research and field opportunities it offers its students. It regularly brings students to national professional association meetings to present their research. Like many geoscience departments, it also sponsors a Geology Club for its students.

Table 4.1

Faculty interviews at Greater Marble State University

Faculty Pseudonym	Years Teaching	Position
Dr. Stratus	18	Professor
Dr. Pyrite	25	Professor
Dr. Shale	20	Professor
Dr. Quartz	11	Associate

Faculty Development Influences

   Dr. Pyrite and Dr. Stratus both described positive experiences related to faculty development. Dr. Pyrite detailed his experiences at a national geoscience teaching workshop. Pyrite appreciated how that workshop required participants to contribute a teaching activity or essay prior to the workshop. He found that these contributions encouraged sharing of ideas about teaching approaches. Dr. Stratus participated in summer working groups as part of an internal Greater Marble grant to design pre-service teacher courses. He worked with colleagues from biology, chemistry, and physics. Many of these colleagues had earned doctorates in science education. Through the working groups and ongoing interactions with these faculty, Stratus has learned much about effective teaching approaches. All faculty also mentioned institutional faculty development opportunities through the learning and teaching center and institutional technology. However, faculty rarely participated in these opportunities.

   Traveling workshop influences. The faculty interviewed were divided as to whether the Traveling workshop was a positive experience. There was agreement that the Traveling workshop gave the department an opportunity to meet as a whole and focus on transforming the curriculum. Dr. Pyrite stated that getting people to discuss strategies was a good idea but, "[i]n the end, it's just a fight." Dr. Shale viewed the workshop as giving people an opportunity to discuss curriculum reform openly. He noted that "it forced everybody to sit down and talk about really difficult issues." However, Shale also reported that following the workshop, the department went through a painful year of discussions. He believed that some in the department still "have hard feelings."

Dr. Quartz and Dr. Stratus recalled the workshop as a more positive turning point. Quartz indicated that the department had been trying to discuss curriculum reform for seven years prior to the workshop. However, he noted that those discussions had never been very productive. The Traveling workshop helped the department to think more about the specific skill sets in which they wanted students to demonstrate proficiency. Quartz also detailed the challenges in addressing the philosophical differences between department members regarding their ideas about what a degree should provide. Dr. Stratus recalled that the leaders of the workshop provided models for how peer institutions addressed similar curricular reform challenges. The leaders provided information that also helped to educate the Dean in how the department lagged peer institutions in instrumentation. Stratus noted that some department members did not see the need for change as the department had been succeeding on many measures, such as matriculation, graduate school acceptance, and job placement. However, he noted that many students went on to fields related to environmental challenges or "water type" careers. In contrast, the department offered a traditional approach focused on rocks and minerals. In the end, Stratus reported that he did not "see that anybody's really losing anything with these changes."

Conversely, Dr. Shale thinks that "no one got exactly what they wanted." While Shale admitted that he had been pushing for change for twelve years, he also detailed how geomorphology courses will no longer be required as part of the new changes. He corroborated what Stratus had reported about the misalignment between their approaches and student needs. Prior to the workshop, Shale prepared five years of data that

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demonstrated that half of the students went on to work in environmental related fields and that less than a quarter were going on to graduate school. He did not want students to think they failed because they chose an environmental path rather than a position in the oil industry. Shale added that the Traveling workshop gave the chair some "outside voices." These voices demonstrated that the changes desired by some in the department were "not crazy."

How Teaching is Described

Each of the faculty described a different favored pedagogical approach that they used in teaching courses for students in the major. These approaches included service learning, problem-solving strategies, interdisciplinary science topics, and inquiry/research-like strategies. Dr. Shale detailed how he infuses undergraduate research-like experiences into all of his courses. When he first joined the department, he realized that involving students in research was considered part of the department culture. He thinks this culture goes back to the early days of the department. More faculty have modeled how to formalize these experiences into their teaching. Dr. Pyrite corroborates this assessment and indicates that "the main thing that links us as teachers would be undergraduate students working on research." Pyrite integrates research projects more in the lab than in the classroom.

Dr. Stratus strives to use very little PowerPoint lecture in his courses for pre-service teachers. With those courses he uses data sets to give students opportunity to work on real world problems in class. He detailed how he uses topics such as *fracking* to integrate interdisciplinary science approaches that are relevant to the public at large.

Stratus knows that his colleagues also use real world situations to give students practical experiences with real world problems such as studying the groundwater in Haiti. Dr. Quartz elaborated on a service learning project he did with a GIS course related to his work in Haiti. He has also brought students to Haiti for longer-term service learning in the field.

Dr. Quartz also teaches some of the large enrollment introductory courses of up to 120 students. He tries to use classroom response systems to encourage more active learning in class. However, he admits that these large classes are not his favorite. He finds it difficult to give students what they need. Quartz is hampered by the physical configurations of the classrooms for large enrollment courses. He notes that only a few of the classrooms are set up for having students work in small groups. Quartz indicated that he will be transitioning away from the large enrollment courses soon.

Dr. Pyrite stated that how the introductory courses are taught is a source tension for the department. Pyrite noted that they have hired instructors that hold masters degrees to teach many of the introductory courses. Pyrite is concerned that these courses are focused more on recalling facts than in learning problem solving skills. Pyrite prefers a problem solving approach to teaching. He adapts the pedagogies he uses in the field to the classroom. He describes his teaching as "messy." Pyrite would like students to struggle, make mistakes, and learn from these errors. He allows students to redo all of their coursework for up to half of the points missed. He struggled to find ways to adapt these teaching strategies to the large introductory courses. Pyrite admits that he has not taught the large introductory courses in eight years.

Valued or Specious Recognition of Teaching

The faculty interviewed were divided as to the value that the institution places on excellence in teaching. Dr. Pyrite and Dr. Shale viewed with skepticism how the department recognizes teaching. Because the department only awards undergraduate degrees, Dr. Shale thinks that everyone would agree that teaching is supposed to be "job one." However, he also indicated that the only way anyone can earn a merit increase is through research. Shale believes that he is a full professor only because of the amount of research he has done. Shale also noted how most of the senior faculty actively work toward transitioning away from teaching general education courses. He also noted that a few faculty in the department are much more focused on research. Dr. Pyrite noted that in the faculty member's first seven years at the institution, more attention is paid to evaluating teaching. However, he stated that it is "a bit of a popularity contest" since it is based on student evaluations. Dr. Pyrite also described how the documentation required for merit increases has changed as it relates to teaching. He characterized the department as having been "forced to institute peer evaluations" and that they are also now "forced to write a document" about their teaching. Dr. Shale also wondered "whether anybody reads that [teaching document for merit increase], I have no idea." With research, Shale noted that it is easier to count papers, grants, and other scholarship. He thinks the institution "gives a lot of lip service to teaching." However, since everyone has the same teaching load, demonstrating improved teaching is a harder case to make. Dr. Shale also noted that teaching awards are given more to the courses for teacher preparation where enrollment is capped.

In contrast, Dr. Stratus indicated that faculty are evaluated primarily on teaching, then scholarship and service to a smaller extent. He described the annual report that each faculty generates for merit raises. He characterizes this report as a teaching reflection. The reflection allows his peers to visualize what he is doing in the classroom and understand that "what you are doing with your teaching is fairly important." Stratus reported how he is in a colleague's classroom several times each year to conduct peer observations. Dr. Quartz thinks that excellence in teaching is weighted heavily by the department. While faculty are evaluated on teaching, research, and service, he believes that teaching is "easily placed on top in terms of importance."

Faculty were also divided as to how they perceived their departmental colleagues' interest in each other's teaching. Stratus thinks that people respect each other's teaching. However, he sees research as a source of friction. He thinks that colleagues place value on different types of scholarship. He stated that it is not possible to force colleagues to contribute in specific ways. He thinks that this "[d]oesn't mean they're not making good, valuable contributions to the department, it just means that somebody else has to do some small task more often. That can ruffle feathers sometimes." Unlike the other faculty interviewed, Dr. Stratus relies on getting teaching ideas from faculty in the other sciences who teach the pre-service teacher courses. They team teach courses together. He observed that with this network there is constant sharing of teaching ideas. He also stated that he is lucky in that the teacher preparation courses have enrollment capped to 24 students. In addition, he is learning new perspectives about pedagogy from an assistant professor faculty who was recently hired into the department. He observed that the

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department have regularly tried to have a faculty member who has more science education expertise but unfortunately "they come and go."

The other three faculty reported that there is very little sharing about teaching within the department. Dr. Pyrite stated that there is not much talk or sharing about teaching. He has relied on workshops outside of the department to get ideas about pedagogy. He admits that the department meets on a regular basis but that the meetings are "the worst parts of the job." He recalls that in earlier years they were able to arrive at consensus but now "minority voices are not welcomed." Dr. Shale indicated that they have had discussions as a department related to teaching approaches for including more authentic research in the classroom. These discussions happen mainly at faculty meetings. He also noted that it is "sometimes kind of adversarial" because people have strong opinions. In the past he has shared teaching ideas with a colleague at another liberal arts college related to his interest in classroom undergraduate research pedagogies. Shale is always looking for ways to be more innovative with large introductory courses. He would like non-major students to gain an understanding of the skills involved in the process of science. He gets ideas more from colleagues in other science disciplines. Dr. Quartz thinks that within the department "people feel like they own a class." He stated that this ownership leads to conflicts related to teaching approaches. Quartz has looked for ideas outside of the department for how engage students. He has found ideas about teaching via social networking.

Geoscience Department at Copper State University

Like other public universities, Copper State experienced challenges related to growth and difficult financial circumstances. Faculty and administration clashed over possible solutions. At one point, the geoscience department at Copper State faced possible dissolution. The department remained intact and leadership has since changed at both Copper State and the state-wide campus system.

Within the geoscience department at Copper State University, six members of the department had participated in an Early Career workshop within the last eight years. The department demonstrates high participation in faculty development. Within the last eight years, nearly three-quarters of the faculty have attended at least one national geoscience faculty development workshop (15 total workshop seats).

While the institution offers masters degrees, the geoscience department awards only bachelor degrees. All 3 faculty interviewed had participated in the Early Career workshop. The interviewed faculty represented disciplinary perspectives from tectonics, geophysics, and geochemistry. The faculty hold associate professorships (2) and an assistant professorship with their years of teaching ranging from 3 to 8 years.

Institutional Background

Copper State University is a regional campus situated in small city of 17,000 residents and serves approximately 18,000 students, of which nearly 16,000 are undergraduates, 1,000 are graduate students, and 1,000 are described as distance education students. More than 90% of the undergraduate population come from within the state and most (86%) identify themselves as white. Nearly two-thirds of the students

rely on financial aid. The campus began over a hundred years ago as a Teachers' training college. Its mission had centered on increasing the literacy of the population within the region that lived in extreme rural poverty. The University's current mission keeps education as its primary focus. Its Carnegie classification is Master's Colleges & Universities: Larger Programs. It offers one Ph.D. (Education Leadership) and offers 37 Master's Degree programs.

Departmental Background

In the last ten years, the department has grown from seven tenure track faculty to eleven tenure track faculty (five full, four associate and two assistant professors). It offers Bachelor of Arts and Bachelor of Science degrees. The B.S. program has four potential concentrations in the fields of paleontology, quantitative geoscience, environmental geology, or secondary education. In support of these different education programs, faculty have specialties in geochemistry, hydrology, biogeochemistry, paleo-ecology, invertebrate paleontology, vertebrate paleontology, structural geology/tectonics, and geophysics. The department offers multiple summer field courses and undergraduate research opportunities for its students. It also maintains a geology/paleontology museum that serves as a focal point for K-12 outreach efforts.

Table 4.2

Faculty interviews at Copper State University

Faculty Pseudonym	Years Teaching	Position
Dr. Malachite	8	Associate
Dr. Adamite	3	Assistant
Dr. Gneiss	8	Associate

Faculty Development Influences

Dr. Adamite compared the faculty development that is offered on campus and her experience with geology-specific faculty development. The institution offers both campus workshops and conferences focused on teaching. There is also a program for early career faculty to join a cohort of other faculty and redesign an entire course. Adamite reported that she participated in one workshop on campus but was not as impressed with it as the geology-specific teaching workshops. She has not taken advantage of more campus options because she received so many good ideas from the geology-specific teaching workshops. In addition to the Early Career workshop, Adamite participated in another national geoscience teaching workshop. What she appreciated most about these workshop experiences was the interactions with other faculty who were teaching the same kind of courses that she taught. She said having the common course experience made it easy to discuss and share teaching ideas. One aspect of the Early Career workshop that she found useful was creating a poster that employed one of the teaching approaches learned during the workshop. Adamite noted the value of the conversations with other faculty about teaching during the poster session. She found it difficult to develop a set of teaching activities "on the spot" and describe these activities to other workshop participants. However, she appreciated learning about the new teaching activities that the other faculty developed. Adamite liked how the Early Career workshop focused on teaching, research, and time management. She finds that one of the most difficult aspects of professional life is balancing research and teaching.

Dr. Gneiss participated in the Early Career workshop immediately after completing his doctorate. He wanted to talk with other faculty "who were in the same boat." Gneiss did not find the teaching sessions at the workshop as useful. He thought the teaching approaches were impractical for course enrollments of 130 students. He did gain a few teaching strategies for teaching quantitative skills that he continues to employ in his geophysics class. The most valuable aspect of the workshop was meeting other faculty who were at the same stage in their career. Over the last eight years, he has collaborated on multiple funded proposals with one of the other colleagues he met at the workshop. Gneiss participated in another national geoscience teaching workshop. He hoped to learn how other faculty approached teaching satellite geodesy. However, he came away from the workshop thinking that few faculty use geodesy data in their teaching. As an outcome of that workshop, Gneiss had been encouraged by the conveners to present his teaching approaches at a national association meeting.

Dr. Malachite reported that the institution does not readily provide funding for faculty development. A faculty member would need to request funds. She stated that there is a teaching center on campus. However, she perceives the center as punitive and not very welcoming. In contrast she found the Early Career workshop as "life-changing." She valued the teaching strategies she learned. Additionally, she gained new ways of approaching her professional responsibilities. She had been newly hired to replace a faculty member who left the institution under difficult conditions. The leaders at the Early Career workshop counseled her about how to manage the departmental dynamics related to the exiting faculty member. She also found the teaching strategies most

influential for how she teaches introductory courses. Moreover, she has kept in regular contact with some colleagues from the workshop. She credits one of those colleagues with helping her find an opportunity to serve on a non-profit board. Malachite thinks part of the value of the geoscience specific workshops lies in its disciplinary nature. She finds it helpful to learn about others' successes and failures related to teaching within the same field. The face-to-face interaction were also crucial to her learning. She prefers to discuss teaching one-on-one with a colleague rather than listening to a webinar-based workshop. Following the workshop, she relied on the Cutting Edge website to find teaching ideas.

How Teaching is Described

The characterizations of teaching that each faculty described were different. Dr. Adamite intersperses her lecture with think/pair/share activities or other demonstrations that involve the students. For example, in crystallography, she has students use marshmallows with partners to create more involved silicate structures.

Dr. Gneiss prefers the lecture section to be "mostly a one-way street." He includes some activities. However, because the lecture time is only 50 minutes, he uses the lab time to give students more interactive learning activities. Because all classes in the major at the university allow for only two 50 minute-periods of lecture each week, Gneiss must give students enough information in an efficient manner. In a data analysis course, he gives students enough computer programming information in lecture so that they are able to put the code into use during the lab section. He likes the idea of a flipped classroom. However, he doubts that students at a state school would complete the work outside of class that a flipped model would require.

Like Dr. Adamite, Dr. Malachite also reported frequently using think/pair/share type exercises in lecture. Her preferred learning environment for students is in the field when she can give them a problem that has no single right answer. She acknowledged that for the large introductory classes with 120 students, it is more difficult to engage students. The active learning approaches may make students uncomfortable. However, she is less concerned about students feeling uncomfortable. Malachite's previous work experience was in deep sea research where researchers may have to work in very tight places. She tells students that with deep sea research "You're in the Alvin [human occupied vehicle]. You have to site on this guy's lap. You don't know him? Too bad. That's what it's like."

Communications Related to Teaching

Dr. Adamite has many conversations with colleagues in the department about teaching approaches. There are three or four faculty who all teach the same course. Among that group of faculty, they discuss what approaches, activities, and assignments have proven to be the most effective. In addition, she discusses teaching ideas and approaches with a research collaborator within the department. They have similar disciplinary training as structural geologists and have each taught the structural geology course. Adamite stated,

> *I do have a colleague here who we work on research together a lot, so we also talk about different teaching approaches. That is sort of related to the discipline because we're both trained structural geologists. He's actually the one who teaches structure, but I've taught it before, so sometimes he'll tell me about ideas and we'll talk about ways to do that and I'll talk about things that I'm doing in the classroom.*

She also discusses teaching with colleagues through conferences, giving talks at different institutions, or being a visiting faculty member. As a visiting faculty member, she was mentored in her teaching by the faculty she was temporarily replacing. That faculty member provided Adamite all of her materials, observed Adamite teaching, and gave helpful critiques for how to be an even more effective teacher.

Like Dr. Adamite, Dr. Malachite also shares ideas with her departmental colleagues about teaching, particularly for introductory classes. She thinks that her colleagues have also received effective teaching ideas from Early Career workshops. She characterized these conversations as informal, asking a colleague if they "have any good ideas for teaching x topic."

In contrast, Dr. Gneiss rarely talks about pedagogies with colleagues in the department. He notes that many of his colleagues are good teachers. However, because his field and teaching specialty is geophysics, he does not think their approaches are as well aligned to his interests. His passion is to get students interested in mathematics, computer science, and physics rather than the outdoor, field geology work. As the number of undergraduate majors has increased, Dr. Gneiss has observed greater variability in students' commitment to learning. Gneiss acknowledged that he strategizes with others on teaching related topics such as how to deal with disruptive behavior. Dr. Malachite had also mentioned these classroom management topics as a common area for departmental discussions.

How Collegiality and Decision Making are Perceived

Dr. Adamite and Dr. Gneiss described their perceptions of department collegiality. Adamite reported that faculty in the department regularly have lunch together and go out together after Friday seminars. Dr. Gneiss noted that that the department used to be tighter knit when there were fewer student majors. He does not think that the growth in enrollment has affected the collegiality among faculty. However, faculty expressed frustration over the issues that arise from the increased enrollment. For example, Gneiss stated that faculty frequently discuss classroom management issues.

Dr. Malachite credits the collegial nature of their department to evenly distributed workloads. She states that "I think part of it is that . . . in terms of research, in terms of teaching, we're all pulling our weight." Malachite stated that few conflicts arise. She reported that the occasional disagreements typically relate to perceived inequities in work distribution. Malachite described how different faculty members who have expertise in different areas will take the lead on issues specific to their specialty, such as environmental science or a particular lab for teaching. She stated that subcommittees will also take on a particular topic. Malachite that the department typically supported subcommittees or different leaders' recommendations.

Dr. Gneiss stated that one of the reasons he is happy with his department is that his role initiating a quantitative concentration was valued and respected by his colleagues. Shortly after Gneiss was hired, the chair asked Gneiss to act as the political champion for increasing the use of computer-based activities. He was so successful that classroom space that had seen little use is now in high demand. Gneiss stated that a

second space was now required for computer-based activities. Gneiss thought his department was unique in how they valued his contributions. He stated that:

> *Other departments that I've been in, the field geologists really resent the quantitative people and think they're not valid scientists, valid geologists, but in my department I think people, even though we had some growing pains, I think my colleagues generally respect what I've done and what I've brought to the table.*

How Teaching is Valued by the Department

Despite Copper State being part of a larger state university system with research priorities, Dr. Adamite reported teaching is expected to encompass 60% of their time. She stated that the department "first and foremost wants people to be successful teachers." She reported that all untenured faculty (tenure track or lecturers) were observed by peers each year. She credited this institutional emphasis on teaching as the reason many faculty in the department exchange teaching ideas. Dr. Malachite reported that faculty all knew and chose to be at the institution because it is a "teaching intensive place." She credits the institution for retaining a strong teaching intensive philosophy from its beginnings as a teachers' college. She stated that the department makes it very clear to potential faculty candidates about the expectations for teaching.

How Teaching is Valued by the Institution

Faculty described a range of perspectives for how much teaching is counted toward promotion and tenure. Dr. Malachite indicated that teaching was factored into tenure. She stated that in addition to student reviews, peer evaluations were used for all tenure and promotion decisions. Dr. Adamite reported that while there were research and service requirements, teaching was extremely important for tenure. Dr.Gneiss noted that

it was not as clear exactly how a faculty member is evaluated on teaching. He characterized tenure as "a mystical thing." Gneiss noted that teaching is evaluated based on student reviews. He described how the policy indicated that a faculty member cannot routinely fall below a 3 (on a 1 to 5 scale). However, it is not clear what is the institution considered "routinely." From what Gneiss had observed, a faculty member could not be terrible at teaching and be awarded tenure. However, he has also not seen anyone who was perceived to be so bad in their teaching that they were not tenured.

Faculty described how institutional measures and expectations related to teaching create barriers to making teaching improvements. Both Dr. Gneiss and Dr. Malachite reported that larger class sizes have negatively influenced what kinds of student work are assigned. With larger classes, Gneiss stated that faculty must employ student assessment methods that allow graded work to be returned to students in a timely manner. In addition, with more students in the major, Gneiss observed that the quality of student work is more variable. Malachite stated that finding time to give students one-on-one attention is difficult with larger class sizes. She appreciates that the writing-intensive courses have a capped enrollment of 16 students. Gneiss noted that the institution's reliance on student ratings can have a negative influence on faculty being willing to take risks with their teaching. He hypothesized that this barrier may be more challenging for untenured faculty.

Dr. Adamite finds balancing competing demands her largest barrier to improving teaching. Adamite has been told that she needs to spend more time on her research

because she is not yet tenured. She stated that it is difficult to find time to redesign classes as much as she would like and also put sufficient time into her research.

How Institutional Leaderships Values the Department

Dr. Malachite noted that the department has had to become more discerning in knowing which battles at the institution to fight. She described the difficult times that the department went through four years ago. At that time, the Provost had slated the department to be eliminated. The Provost questioned whether the department was aligned with the mission of the institution. While the department was allowed to remain, Malachite stated that today they have considerably less funding allocated to the department. Malachite noted that politics and funding decisions at the state legislature have exacerbated funding constraints for many departments. She expressed frustration that the

> *funding structure is such that the only way good teaching is incentivized is if you can be a good teacher for 100 to 200 class [enrollment] of students and yet at the same time, they advertise small class sizes at the upper level so this is the big barrier to me. . .[t]here's just not enough hours in the day.*

Geoscience Department at Jasper State University

The geoscience department at Jasper State University hosted a Traveling workshop program in 2010. When the department applied for the workshop, Jasper State University faced significant funding deficits. The department anticipated that the institution would likely reduce programs and merge some departments. When the department applied to the traveling program, they identified two goals for the workshop. The first goal was to identify the core strengths and values of their department. They

wanted to build upon the increased interdisciplinary nature of the department. In addition, they wanted to put their values in context with the mission of the institution. In this way, they anticipated adapting to changing circumstances. Second, the department wanted to attract more students who demonstrated an interest in environmental issues. They hoped to gain insights into how to adapt their curriculum and teaching to attract and serve more students with environment interests.

The Traveling workshop contributed to departmental discussions about transforming the curricular offerings. Ultimately, the department reduced their program offerings from three tracks and course labels (geology, oceanography, meteorology) to one (earth sciences). As a result, the meteorology degree diminished in scope to a certificate in weather study.

The three faculty interviewed had participated in the Traveling workshop. In addition, one of the faculty had participated in an Early Career workshop eight years ago. Two of the faculty represented the field of meteorology. The third interviewee was a paleo-oceanographer who had applied to the Traveling workshop program on behalf of the department. All three faculty hold full professorships with their years of teaching ranging from 9 to 27 years.

Institutional Background

Jasper State University is an urban campus situated in large metropolitan area and serves approximately 30,000 students, of which over 25,000 are undergraduates. The undergraduate population is racially and ethnically diverse with only a quarter identifying themselves as white. Nearly two-thirds of the students rely on financial aid and over a

third of the first year students are the first in their family to attend college. The University's mission reflects its commitment to its diverse learning community emphasizing equity and an appreciation for roots as well as intellectual development and innovation. The campus began over a hundred years ago as a two-year teacher training college. The focus on education has remained a central aspect of the campus. The mission statement honors a "century-long history of commitment to quality teaching and broad access to undergraduate and graduate education." Its Carnegie classification is Doctoral Universities: Moderate Research Activity. It offers one Ph.D. degree (Education Leadership) and offers 62 different Masters Degrees.

Geoscience Department

The department has seven full, three associate and assistant professors. It offers Bachelor of Arts, Bachelor of Science, and Masters of Science degrees. The B.S. program has three potential emphases in the fields of geology, hydrology, or ocean, weather and climate. The B.A. program is aimed at future K-12 educators, museum careers, or students interested in government or non-profit agencies focused on environmental planning. In support of these different education programs, faculty have specialties in geochemistry, hydrology, oceanography, paleo-biology, paleoclimate, petrology, and structural geology/tectonics. Climate science is of high interest to the faculty with 6 of the 10 faculty identifying "climate" or "climatology" as one of their teaching or research foci.

The department demonstrates high participation in national geoscience faculty development workshops. Within the department, 8 of the 10 tenure-track faculty had

participated in two or more geoscience workshops in the last ten years (combined

participation totaling 25 workshop seats). Over the last 11 years, 3 faculty from the

department had participated in an Early Career workshop. In addition, the 2 department

lecturers had each participated in multiple national geoscience faculty development

workshops within the last ten years.

Table 4.3

Jasper State University Faculty Interviews

Faculty Pseudonym	Years Teaching	Position
Dr. Talc	26	Professor
Dr. Mica	9	Professor
Dr. Obsidian	27	Professor

Faculty Development Influences

Dr. Talc and Dr. Mica detailed the ways faculty development experiences

influenced their teaching to include active learning strategies. Both had formative

experiences early in their career at workshops outside their institution. Dr. Talc had

participated in a collaborative learning workshop at the University of Minnesota. At the

collaborative learning workshop, the facilitators suggested approaches that didn't require

significant expertise to implement. Talc was motivated to try these teaching approaches

because he was dissatisfied with his lecture-based classes. Despite his lack of

sophistication, the collaborative techniques lead to improved student learning in his

classes.

The Early Career Workshop helped Dr. Mica realize that she was not the only

new faculty "who was a deer caught in the headlights." This realization was a huge relief,

particularly when her department included many long-tenured faculty. She appreciated that the workshop addressed how to be effective at both teaching and research. When she first began teaching, she tried to encourage students to interact as part of the lecture. Early Career and other multi-day, national geoscience workshops introduced her to new teaching strategies. Since the Early Career workshop, she has had regular professional retreats several times each year with three colleagues who she met at the Early Career workshop. She stated that every new faculty member in the department has since participated in an Early Career workshop.

Dr. Obsidian recalled his involvement as an invited presenter for the national Preparing for an Academic Career Geoscience workshop eight years ago. At the time, he was the department chair and wanted to share his perspectives as an "elder statesmen" to prospective faculty.

Traveling workshop influences. Dr. Mica had spearheaded bringing the Traveling workshop to her department. All three faculty interviewed discussed how the Traveling workshop was held during a time of curricular transformation. The department was in the process of revising the curriculum for the bachelor degrees in Meteorology and Oceanography. The department was trying to maintain distinct programs. Even though it was Dr. Mica's second year in the department, she argued against maintaining separate programs. The Traveling workshop helped the department to think about their teaching mission of "How do we best serve our students and what is the best education we can provide for them." She noted one of the challenges rested with the rigidity of requirements by the American Meteorological Society for undergraduate degrees. At

their campus many of the students came from first generation families and worked their way through college. It wasn't "doing them a service" when a degree in meteorology took students over 5 years to complete. The Traveling workshop started a conversation about curricular revisions. The ensuing discussions focused on the department becoming more interdisciplinary. Mica thought that the curricular changes addressed some of the concerns related to student degree completion.

Dr. Obsidian characterized the department at that time of the workshop as vulnerable to cuts by administration. Enrollment was low overall. Because student enrollment in the department was divided into three tracks (geology, oceanography, and meteorology), leadership at the university perceived the department as even smaller. By transitioning to the more interdisciplinary program, Obsidian believed that the department now appears larger in the eyes of institutional leadership. Obsidian noted that the dean at the time would not approve courses with enrollments under 13 students. The department attempted to cut back the frequency of offerings in meteorology to increase enrollment. However, this change made it difficult for their students to graduate in four years. As an outcome of the transformation, the meteorology majors program was eliminated.

Dr. Talc also recalled the economic motivations for integrating the curriculum. Integrating the disciplines into one degree was a response to these enrollment problems. Prior to the Traveling workshop, faculty were "siloed" by the separate degrees. The faculty in geology were firmly entrenched in their teaching traditions and the meteorology faculty were entrenched in their traditions. Talc reported that developing

and teaching a climate change course was a groundbreaking way for faculty to collaborate on their teaching. He noted that it was not an easy process given all the strong opinions in the department. Dr. Talc valued the outside leader who came for the Traveling workshop. The Traveling workshop leader identified strengths and areas for improvement. Talc also stated that the department was "riding this wave that seems to be sweeping the country" toward more interdisciplinary approaches.

When Dr. Obsidian recalls the Traveling workshop, he remembers that department morale as very low. The department was determined to build a stronger department from the situation. While Obsidian cannot recall specific details about the day and a half workshop, he valued the outside leader's expertise.

Dr. Talc stated that it is hard to pinpoint how a single event, like the Traveling workshop, contributed to the transformations that have taken place in the department. He views the influences as more collective and that it is "this continuous pattern of input and changes and responses and it's hard to point to one thing."

How Teaching is Described

In characterizing their most energizing teaching moments, faculty described a variety of types of teaching experiences. However, all the experiences shared a focus on students demonstrating engagement with the material. Dr. Talc described his preference for using small group activities in class. He enjoys observing students while they work in small groups on problem sets. With this type of teaching approach, he does not lecture much about content. However, he may be asked by a student to clarify something. He noted that if he were to "step out in the hallway" he would "hear this roar of conversation

coming out of the classroom. There's all this learning going on there, and they don't need me for the most part. That's a real high."

Dr. Obsidian reported his experiences teaching an introductory meteorology course for non-majors. In this course, he has reduced the number of topics he covers. This allowed time for students to master a smaller number of concepts in greater depth. He has students work in small groups where they gather data from online sites and interpret the data as part of the classwork. He gets satisfaction from seeing "a light bulb going on" in students.

Like Dr. Obsidian, Dr. Mica, also described teaching experiences related to introductory courses. Dr. Mica indicated that interactive pedagogies are her preferred approached to teaching including think/pair/share, collaborative learning strategies, and classroom response strategies. Her teaching experience and the research about active learning convinces her of its effectiveness. She also finds that, "it's more fun when you know what's going on out there versus just standing up there and waxing poetic."

Transforming Inhibitors into Assets

Many of the factors that faculty perceived as influencing active learning teaching were present in the Jasper State departmental context. However, Jasper State faculty described how approaches the department took transformed some of these factors into assets. Two of these factors included the classroom environment (configuration and class size) and the language of educational research.

Classroom environment. Dr. Mica reported how the department had proposed and been awarded an NSF grant which allowed them to convert a lecture space into a

learning space with circular desks and computers. She was involved in using this converted classroom space for an introductory oceanography course for 150 enrolled students. With the converted space, faculty were able to use more effective, interactive pedagogy. Mica elaborated about another introductory course related to global warming that the department offered. This course had scaled up to allow up to 700 enrolled students. She and her co-teaching colleague attempt to use more interactive pedagogy, such as think/pair/share, demonstrations, and responsive classroom questions in this mega-class. She finds it an interesting collaborative challenge to make such a large introductory course interactive for the students.

Dr. Obsidian also reported on the same large enrollment course on global climate change. He described how this mega-class allowed the department to overcome a barrier related to meeting enrollment numbers for classes offered in the majors. The global climate change course filled an institutional graduation requirement where few other departments have an offering. Because the department is filling this institutional need with large numbers of students on their rolls, administration allows their department to offer smaller class sizes for their majors. The smaller class sizes in the majors courses allows for active learning approaches and for separate, more regular timing of offerings.

Despite the advantages that the faculty perceive from their strategies of incorporating active learning into large classes, limited time remains an inhibiting factor. For example, Dr. Mica reported that high teaching loads as her biggest barrier to improved teaching. Since she was awarded tenured, her teaching load and service requirements rose. Because of the energy it takes to be interactive and creative with the

global change mega class, Mica has not had the time to invest in being as innovative as she would like for a new course.

Language of Educational Research

Dr. Talc reported an example of a barrier he was able to overcome related to his teaching. The barrier arose from an idea he had to better integrate the lab and lecture offerings for an introductory geology course. As part of that change he envisioned the assigned instructor having more opportunity to mentor graduate assistants in their teaching. However, high level administrators, the chair, and more senior faculty had a negative response to these ideas. When he reviewed the education literature related to evidence-based teaching, he was frustrated by his unfamiliarity with the education terminology in the literature. He stated that "it was so full of jargon and I couldn't make head nor tails out of it." He decided that he needed to collaborate with colleagues in the education department. They applied for grant funding from the National Science Foundation (NSF) to ensure that all colleagues were paid for their time to collaborate. Talc was awarded a NSF grant. He viewed this grant as a critical piece to overcoming administration's resistance. The grant helped him to recruit the range of science and education faculty needed and paid them for their time on the project. The nature of the grant reporting helped keep the group accountable for their collaboration to improved teaching. Talc documented this experience in a talk he gave at the American Geophysical Union about this experience.

Communications Channels and Norms Related to Teaching

All three faculty described an appreciation by their department colleagues for good teaching. In contrast to her graduate school experience, Dr. Mica appreciated that the department values thinking about improved pedagogy. Dr. Obsidian reported that he receives new ideas about using small group discussions in teaching from faculty newer to the department

Dr. Mica reported that nearly all of her colleagues use interactive approaches to teaching. The department is supportive of her taking trying new teaching approaches. However, she doesn't think that this support is typical for other departments within the university. Mica noted that for both introductory oceanography and geology courses, the lab sections are tightly integrated with the lecture sections. Graduate students teach the lab sections and the lecture sections are taught by faculty. Mica described how this allows for the conversations and collaborations about teaching to extend to the graduate students.

Faculty described how the large enrollment course influenced their teaching. Mica reported that brainstorming about teaching is absolutely critical when co-teaching the course for 700 students. The brainstorming between colleagues determines what activities might work with such large enrollment. Dr. Obsidian finds it exciting to observe the large enrollment course. He admired the creative use of interactive strategies employed by his colleagues. Obsidian credits the challenge of teaching such a large enrollment course as bringing about an even greater emphasis on talking about teaching methods in the

department. From his observations and ensuing conversations, he has adopted different teaching strategies.

Dr. Talc also reported examples of collaborations centered on teaching. When he developed a course on climate change for pre-service teachers, he collaborated with a geology colleague, an astronomy colleague, and an education colleague. He stated that he "loved working with a team of people and picking up things from them and watching them learn from the rest of us. Feeling a shared mission to try to do something that I couldn't have done by myself." Both Mica and Talc reported that the education-related grants from multiple colleagues in the department. The interactions associated with these collaborative projects are valued and recognized by the department as a whole.

Department and Institutional Influences

How collegiality and decision making is described. Despite the value the department places on collaboration, Dr. Mica described how the variety of disciplines in the department can cause tension. Because she is a paleo-oceanographer, her field includes geology, oceanography, biology, and meteorology. Because of the multiple disciplines related to her field, she aligns best with integrative teaching approaches that considers how learning makes these connections explicit. She perceived that this affinity may not be true for all of her department colleagues who come from more traditional fields. Dr. Talc reported that not everyone in the department has been as receptive to the transition to a more interdisciplinary curriculum. He stated that both meteorology faculty and geology faculty were alarmed that the transition may be weakening the instruction. Talc stated how meteorology "is probably more like physics than anything else." He

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described it as a strongly quantitative discipline and based on fundamental physical principles that are expressed mathematically. He perceived geology as being more descriptive and conceptual. These differences cause debates related to teaching approaches. He reported an example where departmental faculty debated to what extent students should be able to use software to model phenomena versus students learning how to make observations in the field.

Dr. Mica noted that another source of tension in the department is between the more senior faculty and those hired within the last ten years. She perceived that there is strong collegiality among the newer group. She reported that recent hires understood that research was going to be a key aspect of their professional life. In contrast, she thinks that the more senior faculty were hired primarily as educators with research being a secondary aspect of their professional life. Despite this possible source of tension, she believes that her department is more collegial compared to other departments. Dr. Talc reported that in addition to regular department meetings, the department holds a faculty retreat every year. This retreat allows them to interact with each other for an entire day.

Faculty described how the department is free of much hierarchy, such as committees. Dr. Mica stated that the department recognizes specific faculty as opinion leaders in certain areas. In the past they had tried to require unanimous votes for all decisions. However, they realized that it was difficult to reach agreement in a timely manner. Dr. Obsidian also reported that they were too small for separate committees.

Dr. Obsidian gave an example of how the department makes decisions together. He reported that when the department hires, everyone participates in the interview

process and asks their own questions. Potential candidates are also asked to be a guest instructor for an undergraduate class. The department observes how candidates respond to teaching their diverse student body. Dr. Obsidian has served as facilitator for other department going under accreditation review. From this experience as a facilitator, he has gained a greater appreciation for how well his department works together.

      How teaching is understood to be valued by the institution. Despite the ways faculty described support of active learning teaching, the promotion and tenure process is perceived to be weighted more heavily toward research. Dr. Mica stated that teaching and research are intended to count equally for tenure review. However, reflecting on her experience with the process, Mica does not believe that equal weighting is actually true. She thinks that the institution is transitioning to place greater importance on research for tenure decisions. Despite research growing in importance at the institution and for the department, Mica admitted that faculty will not be awarded tenure if they have received poor teaching evaluations. A faculty member going through tenure review must demonstrate effort toward improving their teaching. Dr. Obsidian corroborated. He reported from his experience having been a former department chair. He stated that, "If your teaching is not good enough, no matter how good the research is, there will be problems."

      Dr. Obsidian reported that it was well known that the outgoing dean was focused more on research than teaching. However, Dr. Obsidian also stated that this dean had allowed the department to make final hiring selections. The dean understood that for this department, it was important that new hires were "genuinely interested in excellence in

teaching." Obsidian reported that the department not only looks for people who are active researchers but also those candidates who are interested in teaching undergraduates. The department shows it commitment to helping new faculty improve their teaching by regularly sending new hires to the Early Career workshop.

Geoscience Department at Southern Gabbro University

The geoscience department at Southern Gabbro applied to the Traveling workshop from a position of strength. They recognized that many in the department had expertise in pedagogy and science education. When the institution issued new mandates related to program assessment, the department applied to the Traveling workshop program. They hoped that bringing outside leaders to the department would allow them to address institutional requirements and become stronger through the process.

Institutional Background

Southern Gabbro University is a regional campus situated in a city of 82,000 residents and serves approximately 15,000 students, of which over 14,000 are undergraduates and a little over 700 are graduate students. Nearly 90% of the undergraduate population come from within the state and three-quarters identify themselves as white. About a third of the students are identified as the first generation in their family to attend college. Nearly half of the students rely on financial aid. The campus began over a hundred years ago as a teachers' training college. The university has a history of innovation in education. During the 1960s, the university developed non-traditional educational approaches that served as models for other campuses. During that same period the campus enrollment tripled in size. It is worth noting that part of the

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vision statement for the university identifies being "an international leader in active learning." Its Carnegie classification is Master's Colleges & Universities: Larger Programs. It offers 8 Master's Degree programs.

Geoscience Department

The department demonstrates high participation in national geoscience faculty development workshops. Within the department, 10 of the 12 (83%) tenure-track faculty had participated in one national geoscience workshops in the last ten years. The average participation in national geoscience workshops was greater than 2 workshops with a combined participation totaling 27 workshop seats. From the department, 3 faculty had participated in an Early Career workshop within the last two years.

Table 4.4

Faculty Interviews at Southern Gabbro University

Faculty Pseudonym	Years Teaching	Position
Dr. Limestone	28	Professor
Dr. Gypsum	3	Assistant
Dr. Basalt	19	Professor

Faculty Development Influences

At the end of his second year at Southern Gabbro University, Dr. Gypsum participated in the Early Career workshop. From the workshop, he learned many of the active learning strategies that he uses every day in his classes. Despite being a more recent faculty member (earning his Ph.D. in 2007), he reported that he "basically grew up on a diet of just lectures." From the Early Career workshop he had an opportunity to practice techniques such as jigsaw and gallery walk. In addition, he made important

professional contacts. He has written grants and collaborated on research with the colleagues he met at the workshop.

Dr. Limestone also learned about active learning teaching early in his career. Rather than a workshop, he credits his learning to the mentoring of experienced faculty at the first institution where he held an appointment. The institution used a block plan which allowed for extended class time in the field. These mentors showed him the importance of observing students while they grappled with problems. In his next appointment he had more experience and confidence to bring more inquiry-driven and active learning strategies into the classroom.

Dr. Basalt could not recall any faculty development opportunities outside her institution. However, she notes that she learns great ideas from the education sessions at the American Geophysical Union and Geological Society of American meetings. She finds that interacting with colleagues about teaching and hearing their education talks are important learning experiences for her.

Traveling workshop influences. Dr. Limestone detailed the motivations for applying to the Traveling workshop program in 2011. At that time the university as a whole was urging departments to improve assessment. As a department they discussed whether they wanted to work on assessment in order to meet compliance or whether they wanted to work on it to improve the program and the courses they offered. Limestone stated that the department had a candid discussion about the level of energy they were willing to spend on the effort. In the end they wanted to have the effort be of value to

them for program improvement. The Traveling workshop was viewed as a means of moving them forward on this effort.

Both Dr. Limestone and Dr. Basalt commented on the value of the examples which the Traveling leaders supplied. Limestone reported the importance of the entire department participating in the workshop. In addition, he viewed the discussions about the value of pedagogy and assessment which department had leading up to the workshop as essential. Without this departmental-wide knowledge about effective pedagogy and the value of assessment, the strategies proposed by the Traveling workshop program would have seemed overwhelming. Dr. Basalt recalled that the examples provided by the Traveling leaders, "turned on a lightening bolt" for the department. Following the workshop, the department developed a matrix which identified the type of student learning desired for each course.

How Teaching is Described

Dr. Limestone prefers a teaching approach where he can stand back and observe student groups "discussing, arguing, coming up with solutions and then comparing and interacting as they're presenting and asking questions of each other." He reported an example using this approach which he and a colleague developed thirteen years ago. They developed an activity where students create a river-delta formation. The students then physically dissect it, make measurements, and evaluate their hypotheses. The set of activities addresses many commonly known misconceptions related to measurement and scale. Limestone particularly likes this activity because nearly all of the students have "an

'aha' moment." He also noted that it is particularly meaningful that he can recall the first time this activity was developed with his colleague 13 years ago.

Dr. Gypsum described how he is phasing out lecturing with PowerPoint and including more active learning strategies. He finds this transition easier now that he has taught courses multiple times. He makes notes about where students struggle so that the next time he teaches the course he can try a different pedagogical approach. He finds that it no longer seems like additional work to include active learning strategies. For example, he reported that it can take more effort to create detailed PowerPoint lecture slides when a concept sketch activity may get across the learning with less instructor effort.

Dr. Basalt splits her teaching load between geology courses related to her field and science education courses aimed at pre-service teachers. For the teacher preparation course, she views her role as a facilitator. Students work collaboratively in groups on activities and discussions. It has taken her and the other science faculty several years to refine this pedagogical approach. More recently, she has adapted those teaching strategies to a traditional geology course in petrology. She redesigned the course from a traditional lecture and lab format to a studio-format where hands-on activities are integrated throughout the class. In this course she sets the tone that students should not be afraid to be wrong. She feels strongly ". . . that it is important for students to be able to create that structural frame work for their understanding. "

Working Around Barriers When Possible

Faculty reported perceptions about several of the factors commonly understood as barriers. When possible the department looks at ways to mitigate barriers. As Dr.

Limestone noted that as a department "[w]e recognize barriers. We try to lower barriers when we see them." These factors included the classroom environment (configuration, class size, and field learning) and teaching loads.

Classroom environment. All three faculty reported their experiences teaching large introductory courses (around 150 students). Dr. Limestone described two strategies that he and colleagues used for the large introductory courses. As part of a National Science Foundation initiative that the institution was awarded, a visiting astronomer shared a teaching strategy which used colored, lettered cards as a substitute for classroom response systems. Limestone found the using the teaching strategies with these cards dramatically changed the dynamics of the large courses. Within a single quarter, the department went from order 50 of these cards to ordering over 600. Now most of the faculty are using this teaching strategy in the large introductory courses. Limestone also described a flipped classroom strategy that he tried with the introductory courses. He had become skeptical as to whether students were reading the textbook assigned to the course. He collaborated with three other faculty who were teaching the introductory course to use an electronic version of readings that included an assessment which students would complete prior to class. By using this model, they were able to free up more time in class to use active learning strategies rather than lecturing on content. Because of the logistical challenges of trying some of the interactive activities in the large classes, the colleagues even helped in each other's classrooms. However, Limestone stated that he did not want "to make it all sound rosy." The flipped model was frustrating for the faculty involved. They were not convinced that students learned as much as they hoped from the

interactive activities. He also reported that a few faculty have completely given up trying the flipped approach with the large classes. Some faculty returned to lecturing and only assessing what is in the lecture.

Dr. Basalt and Dr. Gypsum reported their perceptions about these large enrollment courses. Basalt stated that she struggles with the large lecture courses. She has observed others in the department who excel in these classes and tries to learn from their approaches. Dr. Gypsum reported that that three or four faculty who teach the large introductory class regularly collaborate on their teaching approaches. He named Dr. Limestone by name as a leader and influential resource for others teaching these classes.

Despite colleagues trying different approaches to making the large introductory courses interactive, Dr. Limestone noted the limitation of the room configuration. He described the classroom design for these classes as lecture theaters, sloped with fixed seats. In order to try small group work as part of the class, he tried to manually number all of the seats. He found it time-consuming and logistically challenging. He also reported that it "is a barrier that is so big that nobody else is willing to even try."

Dr. Limestone stated that teaching in the field is considered an important component to their interactive, inquiry style teaching. The department faced a challenge with transportation costs for students associated with rental vans. Through a generous alumni donation, the department decided to purchase their own vans to use for teaching in the field.

Teaching loads. One of the aspects that Dr. Gypsum appreciates about the department is the equity in teaching loads. No one is holding a research-only appointment

or is bought out of their teaching load. Since teaching is a large component of all their professional work (five classes per year), he believes it drives so many discussions about teaching among faculty.

In contrast, both Dr. Limestone and Dr. Basalt expressed frustration with the high teaching workload. Each stated that this teaching load makes it difficult for co-teaching and peer observations to occur. Limestone expressed a sense of obligation to observe his colleague's classes. He discussed his frustration with not having the time for these observations and ensuing the conversations that all the department value. Basalt expressed frustration about the high teaching load not allowing enough time for reflection about teaching. She would find the large introductory classes particularly challenging because she would not have enough time to learn about and adopt the strategies involved. Basalt thinks that the largest challenge to faculty who want to improve their teaching is "just not having time to think."

Dr. Basalt reported a story about a colleague in biology who completely restructured a course for active learning with a flipped classroom approach but the students hated it. The colleague "put so much time and energy into it . . . The student evaluations were just utterly terrible. . . in the end he asked, why am I bothering?" Basalt reported that the institution places high value on student evaluations. The emphasis on these evaluations along with constraints of time may limit faculty experimenting with their teaching. She reported this barrier as "maybe fear of experimenting and failing."

Expectations and Communications Related to Teaching

All faculty described how frequent informal conversations about teaching helped their own thinking about teaching. Dr. Limestone characterized the department as a "very questioning group." If someone tries a new teaching strategy, others will ask about the pedagogy, its effectiveness, and "what is the key to doing it right?" Dr. Basalt stated the conversations she has had with the different science faculty who teach preservice courses and the colleagues within her department. She thinks that everyone in the department aims to make their classes more interactive. Dr. Basalt indicated that while discussions about interactive teaching techniques happen frequently, it is not an everyday occurrence. She cautioned that the department was not a "teaching utopia. . . everybody is really busy, so it doesn't happen probably as much as would be nice." Dr. Gypsum reported that because faculty in the department are in their offices or on campus most of the time. This time on campus leads to frequent conversations about teaching. He also stated that there are regular email threads from different department colleagues related to teaching and assessment.

Dr. Limestone described how the value of effective teaching is understood from the initial hiring process. Potential candidates must submit a teaching philosophy statement that is evaluated based on the department's collective stance toward teaching. In addition, Dr. Basalt detailed how a candidate must teach a class and be observed by the faculty. The department will discuss to what extent the candidate's teaching approaches were effective. Dr. Gypsum thinks that the hiring process contributes to the collegiality of

the department. By identifying candidates who realize the importance of good teaching and strong scholarship, the new faculty will fit into the department.

Dr. Basalt described how teaching is factored in tenure and into later merit considerations. She indicated that everyone realizes that teaching is quite important. For tenure, faculty are evaluated equally between their teaching and their research scholarship. After tenure, faculty are evaluated on what all three faculty referred to as a "three legged stool" between scholarly research, teaching, and service. She doesn't know of anyone who has been denied tenure because of their teaching. However, her impression is that everyone is striving for excellence in teaching.

Dr. Gypsum is in the process of going up for tenure. From reading the assessments about his teaching and scholarship, he would say that both are equally weighted by the department. Gypsum perceives the equity in the teaching load as another way that he perceives it is important to be a good teacher and a good scholar.

Dr. Limestone corroborated Dr. Gypsum's impressions. Limestone indicated that the department expects solid teaching credentials that rely on more than student evaluations. Faculty must be able to write about their courses and pedagogy in a knowledgeable way. Dr. Basalt and Dr. Limestone agreed that peer observations are not as frequent as they would like to see in the department. They both indicated that peer observation is used in informing tenure. Limestone noted that on occasion, senior faculty will observe whether a more junior faculty member's dedication to pedagogy makes them vulnerable for tenure reviews. He stated that these junior faculty are interested in pedagogy but are not publishing about it. The senior faculty will advise the junior faculty

member to refocus on research and publishing. He indicated that being sufficiently productive is critical for the institutional tenure review process.

Limestone reported that in his sixteen years at Southern Gabbro, the department has maintained a high standard for instruction. Recently, Dr. Limestone transitioned into an administrative position that gives him opportunities to interact with departments across the university. From his observations he does not see the same attention placed on teaching and that other departments, "don't talk about teaching with each other the way we did in geology."

All faculty valued the collegiality of the department. From Limestone's new external perspective, he views the professional sense of the community in the department as "the best I've ever seen." He attributes their collegiality to the importance placed on mutual respect. He described the range of contributions different faculty make with scholarship and teaching expertise. He also stated how the department has a history of responding with respect to life balancing situations. Dr. Basalt described how the department works together toward common goals. She gave the example of developing a common vision toward assessment outcomes and that the department "had an awesome time" when developing the matrix. Dr. Gypsum indicated that the sense of collegiality was one of the reasons he was so excited to join the department. He echoes Limestone's perceptions and reports that "everybody brings something to the table."

Disciplinary Influences on Teaching

Dr. Limestone reported his experiences related to a workshop about teaching geomorphology. The conversations with colleagues in his field validated his pedagogical

approaches within his field. His scholarly research related to landslides but he does not

tap that professional network as much for teaching ideas. At Southern Gabbro, he

indicated that faculty have regular conversations about balancing core traditional

approaches in service to professional licensure with teaching that embraces the idea of

depth.

Dr. Basalt indicated that even though her field is in hard rock geology, she has a

different perspective on professional licensure. She thinks that it is more important that

students learn deeply a few key fundamental concepts. By having this deep learning, she

thinks that students will be well equipped to fill in their own knowledge gaps at the

appropriate time in their professional life. Because of her experience with the group of

faculty who teach science education to pre-service teachers, Basalt has had an

opportunity to regularly share teaching ideas across science disciplines. She notes that

while faculty from different disciplinary backgrounds may approach teaching a concept

or skill in a different way, they share a common set of values about teaching science. She

enjoys collaborating on teaching with faculty from different disciplinary backgrounds

Geoscience Department at University of Olivine

Since 2004, the geoscience department at University of Olivine has sent 6 of its 21

(28%) faculty to Early Career workshops. All 3 faculty interviewed had participated in an

Early Career workshop within the last 11 years. In addition, one of the interviewees had

served as an invited trainer at Early Career workshops. The faculty represented different

disciplinary perspectives and research interests which included geophysics, paleobiology

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and paleoclimate, and structural geology/tectonics. All three faculty held associate professorships with their years of teaching ranging from five to twelve years.

Institutional Background

The University of Olivine is situated in a small city which serves as a regional center for the area. The University serves approximately 37,000 students. The largely white (86%) student population makes up nearly 40 percent of the city's population. This research university (Carnegie classification: Doctoral Universities: Higher Research Activity) is the state's oldest public university. In the last ten years enrollment has nearly doubled in size. During this time enrollment transitioned from drawing regionally within the state to being a campus where the majority of students identify other states as their primary residence. The mission statements of both the institution and the department which houses the geoscience programs focus on providing strong education and research programs.

Geoscience Department

The department has 7 full and 14 associate and assistant professors, 2 of whom are part-time administrators outside the department. It offers Bachelor of Arts, Bachelor of Science, Masters of Science, and Doctoral degrees. The B.S. programs are in the fields of marine science, geology, or interdisciplinary science which requires more chemistry, physics, and mathematics and less geology. The B.A. program is aimed at future K-12 educators, environmental lawyers, or students interested in the business side of geology-related industries. In support of these different education programs, faculty have

specialties in geochemistry, hydrogeology / oceanography, geophysics, paleo-biology, paleoclimate, paleo-environmental science, petrology, and structural geology/tectonics.

Table 4.5

Faculty Interviews at University of Olivine

Faculty Pseudonym	Years Teaching	Position
Dr. Current	12	Assistant
Dr. Feldspar	11	Assistant
Dr. Epidote	5	Assistant

How Teaching is Described

The faculty described their experiences teaching large introductory courses as the most rewarding. These classes take place in theater-like spaces with up to 260 enrolled first year students. While all admitted that the majority of the students enrolled in these courses will never be geoscience majors, faculty reported the charge they experience from transmitting their disciplinary passion, sparking students' interests, and watching students be surprised by new knowledge. The three faculty's preference for teaching introductory courses may not be typical of others in their department. Dr. Feldspar noted that he was a little unusual among his colleagues because he gets a kick out of teaching large introductory courses.

The three faculty shared an interest in trying active learning teaching strategies even in the large introductory setting. Dr. Current, described a class peppered with think-pair-share and clicker activities. He extended his approaches for student-to-student interactions to offering collaborative, short answer exams with each student submitting their own answers following group work. With smaller enrollment courses for those in

the geoscience major, Current uses flipped classroom strategies to maximize opportunities to work on geophysics-related problem sets in class and keep his lecturing time to less than five minutes.

Dr. Feldspar was more ambivalent about active learning teaching. He reported that he likes to experiment every semester and try new approaches, such as role playing. However, Feldspar also considers the student audience when trying active learning approaches. He doesn't want to alienate students and have students disengage as with "most of the active learning techniques, the feedback I get from students is really negative." Feldspar noted two institutional factors that influence to what extent he uses active learning techniques. Both the rapid growth of enrollment at the university and the growth in the number of students majoring in professional degree programs has limited how often he uses these techniques. For large introductory courses, he finds that active learning strategies work better later in the semester when students are more comfortable with each other and the coursework.

Dr. Epidote, the most junior of the faculty interviewed, characterized her preferred teaching approaches as using interactive activities to break up lectures. Epidote reported that she most often uses demonstrations to keep students engaged in the material. Even with the large sections of 110 enrolled students, she tries to find some ways to give students hands-on experiences. Epidote described bringing in balloons for students as an activity to illustrate the different bonding related to electrons. She also relies on her research experiences in Antarctica to provide real-world examples within her lectures.

Communications Related to Teaching

The faculty described conversations about teaching as happening informally most often with departmental colleagues. Dr. Current expressed frustration about these conversations. He wished that the type of conversations about teaching that he has with faculty at workshops happened more often in his academic department. Dr. Current noted that even when faculty in his department participate in teaching workshops, there is never time to pause and think about teaching when they return to campus. He holds deeper conversations about teaching with colleagues at other, more teaching oriented universities. These conversations also happen informally, usually over a beer at national professional meetings. He noted that he regularly shares his geophysics course materials with geophysics colleagues at other institutions.

Current noted that he spends "a lot of time talking to my colleagues and saying, 'Hey, these are some things you could do,' the typical answer is, 'I just don't have time to do that sort of stuff.'" However, his advice is not as unappreciated as he perceives. Dr. Feldspar named Current as a positive influence to his own teaching. Feldspar appreciated how Current shares information about teaching successes and failures. Feldspar stated that when Current gets excited about a new teaching approach, ". . .he gets really excited about it. He'll be pushing all of us to do this [approach]." Feldspar also described the range of ways departmental colleagues share teaching ideas. He reported that they share online teaching resources via email, meet with authors of textbooks, and even collaborated over a period of time on a large set of test bank questions.

Dr. Epidote described sharing ideas about teaching with colleagues both within the department and at other institutions. She recently received a humorous teaching video related to geoscience from a colleague at another institution and added it to her class. Dr. Feldspar also described this same video which he noted had become widely used by faculty in the department. Epidote stated that because so many of the faculty are assigned to teach the introductory courses, these colleagues get together to discuss effective teaching approaches for these courses. In this way, stealing good ideas about teaching is encouraged.

Dr. Current reported that he learns new ideas about teaching from newer faculty. He finds that more senior faculty in the department have taught the same way for over 25 years. In the past he had conversations with these senior faculty about their teaching approaches. He tried to get these faculty to explain why they believed students on the educational path to become lawyers should need to memorize mineral formulas. He is pleased that now the department has a different approach to these classes. Now faculty consider more thoughtfully what knowledge about geology students need to understand to be a good global citizen.

Department and Institutional Influences

How collegiality and decision making is described. All 3 faculty characterized the department as very collegial. Dr. Current characterized the department as a socialist collective. It is important that everyone in his department has an opportunity to talk. He confessed that he can get frustrated with how much it takes to put an idea into motion. Current described the time it takes time to sell an idea, get input from all the stakeholders,

and get departmental members to buy into the particular idea. Dr. Epidote thinks the committee structures used by the department is effective. She reported that a given committee will take on smaller tasks and bring back information to the department as a whole. Then, she stated that it is "all hands on deck," depending on the scale of the decision. Dr. Feldspar reported that even though the department is very collegial, there is conflict. He thinks that some of their conflict mirrors the tension felt in the whole discipline of earth science which he described as "in an identity crisis." The department is shifting the undergraduate curriculum to be less rock focused and more interdisciplinary. Feldspar stated that it is sometimes difficult to have graduate Teaching Assistants (TAs) support the interdisciplinary classes. The graduate TAs come with more traditional geology skill sets rather than the climate or environmental science backgrounds. Feldspar reported that one can see this same "identity crisis" in evidence from the programs at the national meetings for the Geological Society of America and the American Geophysical Union.

Dr. Feldspar reported that the shift to interdisciplinary curriculum can lend itself to active learning teaching. As a climate scientist, he finds that it is important to consider how climate changes in response to life, tectonics, and ocean structures. To cover all these aspects and to illustrate the interconnectedness of it, he finds it easiest to have the class work in small groups. The small groups may include students from a range of majors such as a group with a marine science student, an anthropology student, and a petrology-focused student. Feldspar reported a recent example from one of his classes

where this strategy gave students new avenues for being the experts about different aspects of climate for the rest of their class.

Feldspar also reported an example where the range of disciplines in the department posed conflict related to the content of the materials taught. He and one of his colleagues both teach a sequence of courses on stratigraphy. His colleague's focus was more on terrestrial basins as that was her research. She taught the first course in the series. However, since he is a marine focused researcher, he thought it was important to understand sea level variation. He was frustrated that students didn't have an understanding of sea level as part of their previous coursework.

How teaching is understood to be valued by the institution. All 3 faculty reported that the institution gives annual teaching awards. Dr. Current reported that he had been the recipient of such an award. In contrast, Dr. Epidote said that she doesn't know anyone who has received a teaching award. She believes that these awards are more for those faculty in the liberal arts departments.

Faculty described their impressions of the metrics used for promotion, tenure, and merit decisions. Dr. Current reported that getting published and receiving grants was valued more highly than teaching in the college and in their department. He stated, "For example, you can get tenure and be a really bad teacher, but if you're getting the grants and publishing, you'll be fine. If you're an excellent teacher, and you have an award, or awards, but you don't have that research element, you won't get tenure." Current believes that those faculty who bring in funding are valued by the institution and that teaching is considered secondary. Dr. Feldspar reported that the campus teaching workshops are

required for tenure. He stated that upper level faculty are bribed by the college to participate in these campus teaching workshops with research money. Dr. Epidote reported her experiences of recently going through the tenure process. From her perspective, the institution placed a big emphasis on research, publications, and receiving grant funding. She was told that she needed "adequate teaching" for tenure. She believed that teaching is judged for tenure mostly based on student evaluations. These evaluations are optional for students. In her experience, it is the students who either really liked or hated the instructor that complete the evaluations. She said that a faculty member going through the tenure process could request a senior faculty member to observe and evaluate their teaching. However, while that type of request was possible, it was not done on a regular basis.

Perceived values of institutional leaders with regard to teaching. Both Dr. Current and Dr. Feldspar reported their perceptions related to how leadership at the institution views and values teaching. One year ago, the University hired a new President and appointed a new interim Provost. Current observed that these new administrators have more recently held teaching positions compared to the previous administration. The new leadership urges those in administration to include teaching loads as part of their appointment. Current stated that this is a change in philosophy from the previous leadership.

Perceived barriers to teaching related to institutional context. All faculty identified large class sizes as a deterrent to adopting active learning teaching strategies. Dr. Current had proposed adding more flexible learning spaces for the larger classes to

the previous Provost. The administrator had responded that, "Once you get above 20 students, it doesn't matter. Lecture halls work just fine. There's no difference, doesn't matter if it's 20 or 260." Dr. Feldspar also reported that larger enrollment classes have a negative impact on offering experiential learning opportunities. He stated that when one of his courses had an enrollment of around 12 students, he could organize outside of class learning experiences along the coast using boats. When his class size doubled, the department lacked sufficient funds to continue this type of class field trip.

Dr. Current also identified time as a barrier to both faculty and the institution. He observed that his colleagues are, ". . . just trying to keep up and they're just teaching the same old way." He also expressed frustration that the institution didn't take more time to develop teaching workshops. The workshops offered at his own institution appear "thrown together."

Faculty Development Influences

The faculty each endorsed their Early Career workshop experience and criticized faculty development experiences at their own campus. Dr. Current credited the Early Career workshop with helping him formulate his approach to teaching. Prior to the Early Career workshop, Current had had no formal training on how to instruct. What he learned from the Early Career workshop, he characterized as "an eye opener." He viewed the conversations and ensuing relationships he developed with faculty from that workshop as essential to helping him become the type of instructor he is today. Dr. Feldspar valued how the pedagogical approaches were modeled at the Early Career workshop. For Feldspar the holistic approach of the workshop was important. He appreciated how

pedagogy was discussed along with topics such as creating a research agenda and managing time pressures. The acknowledgement of multiple facets of professional life made a difference for him. In addition, Feldspar felt like his opinion was valued by fellow participants and workshop leaders. He believes that every new hire in the department has since attended the Early Career workshop. Feldspar stated that the dean will pay for any faculty member to attend a pedagogical conference. Dr. Epidote stated that her biggest takeaway from the Early Career workshop was the feeling that "You are not alone." The workshop helped her understand how to juggle the different aspects of a faculty career. She remains in touch with colleagues she met at the workshop. These colleagues from other institutions are there to commiserate with her when aspects of her career are overwhelming or to celebrate with her on her accomplishments.

In contrast, all three faculty shared frustrations about the institutional faculty development workshops. The institution requires attendance at annual campus teaching workshops. Feldspar and Epidote both noted that monetary incentives were needed to encourage attendance at these workshops. Dr. Current believed that administration lacked real investment in faculty development. Current acknowledged that administration knew that the institution should offer some type of training related to teaching for faculty. However, he was not sure that administration had the right people running these workshops. Current noted that unlike the Early Career workshop which models active learning, these workshop lecture about active learning. Dr. Epidote indicated that the institutional teaching workshop she attended was ". . .a train wreck. They had to pay people to go to it because otherwise nobody was showing up." She described how the

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workshop tried to use a one size fits all approach across disciplines and that she didn't find that it worked. Dr. Feldspar expressed frustration with the campus workshop focused on assessment. Even though his department had glowing reviews from accreditors on assessment, they were told they had to change. He believed that all the faculty in attendance thought they had to "shut their mouths" or they would get "in trouble" for asking questions. Feldspar had a similar negative experience with an active learning national workshop sponsored by a consortium of universities. Feldspar reported that he gets his best ideas from friends, colleagues, web resources, and chatting in the hallways. When workshops use a lecture approach and include excessive education jargon, he feels alienated and excluded.

Both Dr. Feldspar and Dr. Epitome described the language of education research as a barrier. Dr. Feldspar stated that workshops which are heavily filled with that type of jargon run counter to their purpose as the jargon alienates faculty. Dr. Epitome reported her experience writing a grant proposal for funding to provide experiential learning. She heard that the proposal had reviewed well but "didn't use the right lingo." She expressed frustration that in order to gain funding for innovative learning environments, faculty already have to "talk the talk as well as somebody who has an education background."

Geoscience Department at University of Granite

The geoscience department at the University of Granite hosted a two day Traveling workshop in 2011. They applied for a Traveling workshop to serve three purposes. First, they wanted to focus their undergraduate curriculum on maximizing the expertise of new faculty. Second, the faculty wanted to explore the introduction of an

environmental science track into their undergraduate program. Third, they wanted to revise their approaches for engaging students to be more current and attract new undergraduate students. Because of the geographic distance between their institution and other campuses, they stated that they may fall behind in movements related to science teaching. At that time, they had 6 teaching faculty and 13 research faculty who had joint appointments with an affiliated research institute. Teaching faculty could teach up to 4 courses per academic year. Research faculty typically taught 1 course per year.

All the faculty interviewed had participated in the Traveling workshop. In addition, one of the faculty had participated in 2 other national geoscience faculty development workshops prior to her Granite appointment. One of the faculty represented the "hard rock" field of structural geology. Another faculty represented the "soft rock" field of sedimentation and environmental geology and held a joint appointment at the research institute. The third faculty worked in the field of theoretical geochemistry. Two faculty held full professorships and one held an assistant professor appointment. Their years of teaching ranged from 4 to 35 years.

Institutional Background

The University of Granite is situated in a city of 30,000 residents and a broader metropolitan area of nearly 100,000 residents. As the second largest city in the state, it serves as a regional center for the area. The University serves nearly 10,000 students, of which 9,000 are undergraduates, 1,000 are graduate students. This research university (Carnegie classification: Doctoral Universities: Higher Research Activity) is the state's oldest public university. Over the last thirty years, enrollment has doubled in size. The

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undergraduate enrollment draws almost exclusively from within the state and the graduate school draws enrollment largely from outside the state. The mission of the institution focuses on its role as an international center for research, education, and the arts.

Geoscience Department

The department has 10 full, 8 associate and 5 assistant professors. Of these 23 faculty, 13 have joint research appointments with a research institute. In addition, there are 20 research faculty affiliated with the department but who have dedicated appointments to the research institute. Finally, there are 28 other faculty affiliated with the department either through another specialty center or by teaching a course for the department (such as petroleum engineering or atmospheric science). The department offers Bachelor of Arts, Bachelor of Science, Masters of Science, and Doctoral degrees. The B.A. in earth sciences program has three emphases: earth systems science, geological hazards and mitigation, and secondary education. The B.S. in geosciences has four options: geology, geophysics, geospatial sciences, and paleontology. The department website indicates that the varied options for the bachelor degrees ". . . are designed to better prepare students for admission to competitive graduate programs and/or successful careers in industry, while new courses take advantage of recent faculty hires and growing departmental strengths in geophysics, tectonics, remote sensing and vertebrate paleontology." In addition to eight faculty in the field of geophysics, other disciplines represented include ecology, geography, vertebrate paleontology, climate science, geomorphology, tectonics, structural geology, volcanology, and geochemistry. There are

two options for the M.S. and Ph.D. degrees in geology or geophysics. Not quite a third of the faculty in the department (7 of 23) have participated within the last twelve years in at least one national geoscience faculty development workshops (in addition to the Traveling workshop).

Table 4.6

Faculty interviews at University of Granite

Faculty Pseudonym	Years Teaching	Position
Dr. Slate	35	Professor
Dr. Galena	4	Assistant
Dr. Sandstone	20	Professor

Faculty Development Influences

Dr. Galena stated that she had learned about teaching using hands-on activities through a geoscience career preparation workshop. She is motivated to use these approaches in order to engage students more in their learning during her 90 minute lecture sections. Galena stated several positive outcomes that she attributed to the Traveling workshop. First, she stated that as a result of the workshop, the department unanimously decided to offer a required plate tectonics course. Galena will teach that course and expressed enthusiasm for it. She thought that the workshop also helped communications between faculty and the undergraduates in several ways. First, following the workshop faculty developed a flow chart designed to communicate with students the order in which undergraduates should enroll in courses to meet graduate requirements within four years. Second, the department introduced a field trip for incoming majors. In addition, the department introduced three annual parties so that students would connect "on a personal level with their instructors." Finally, Galena thought that for faculty "who

were already interested in adopting new teaching techniques that [the workshop] inspired them to continue to do that."

In contrast, Dr. Slate recalled that faculty failed to show enthusiasm for the ideas at the workshop. Slate did not see much commitment from faculty following the workshop for any of the ideas. Dr. Sandstone recalled that "during the workshop we sat around and kicked around a lot of ideas." He attributed reinstituting a geophysics emphasis as a result of the workshop. Sandstone thought that the idea of a Traveling workshop worked well because it involved more of the department directly in comparison with sending a few faculty to a national workshop. He recalled that the faculty who wanted to bring the Traveling workshop to the department hoped to foster focus on what the department offered undergraduates. They found value in gathering outside perspectives from workshop leaders.

How Teaching is Described

All faculty interviewed described how they incorporated some hands-on activities in order to encourage interaction during the lecture, rather than passively listening to the instructor. Dr. Slate uses hands-on problem sets during the class time to help students make connections with the material. He stated that he "can babble all I want to, but nothing really sinks in until and unless the student makes the connection." Dr. Sandstone reported a similar approach. He indicated that he tries to integrate at least one opportunity for students to work with data "in every class section just to get a little more direct interaction with the students and not have them just sitting there listening to me the whole

time." Dr. Galena indicated that she approaches her teaching in ways that allow her to develop relationships with students in the classes.

Dr. Sandstone described his observations for how the department had evolved in terms of teaching practice. Twenty years ago, Sandstone characterized the favored teaching approach as the integration of PowerPoint into lectures. About ten years ago, he observed that faculty in the department shifted to incorporate more hands-on approaches or visualizations as a means of breaking up lectures. Sandstone credits the newer faculty in the department of modeling active learning pedagogies.

Dr. Slate described an example of a change he made to his teaching practice. About ten years ago, he transition to requiring students to complete their problem sets using Excel. By requiring students to use Excel, he could better identify where in students' work they encountered errors. Then, about five years ago, Slate sought to better scaffold students through the problem-solving as part of the class period. He experimented with different teaching approaches to encourage interaction from students while talking through problem sets. However, he found that in practice, he could not engage all of the students all of the time. Inevitably, a few students would be waiting to move forward while the other students required more instruction. While the strategies did not work as well as he hoped, he remains convinced that working through the problem sets holds merit and continues to try such approaches in the recitation sections.

Both Dr. Galena and Dr. Slate observed the challenges of teaching the large enrollment introductory courses. Dr. Galena censured the large enrollment courses which limited her ability to interact with students in meaningful ways. She observed that higher

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education appears to operate using a business model. Her department realizes a certain amount of funding per student in a course. Therefore, it is important for them to offer large enrollment introductory level courses. She likes the idea of exposing large numbers of student to science. However, she struggles with how to impact these students in a significant fashion. Dr. Slate used to teach an introductory geology course to over 120 students in an auditorium setting. He team-taught the course. He and the other instructor tried to incorporate as many hands-on exercises as was possible in the space with that size enrollment. Nonetheless, Slate found the combination of the space and enrollment size frustrating.

Disparate Types of Appointments within the Department

When Dr. Galena characterized her teaching, she stated that it was important to understand the teaching context of the department. She described her struggles with a teaching load of four courses per year that includes large enrollment introductory courses and lower level courses for the major. Because of the nature of these teaching assignments which occupied the majority of her time, she feels constantly pressed for time. She reported that "some of it [teaching] is more like I'm fulfilling this obligation that I don't necessarily love fulfilling." She reported that very few faculty in the department have the teaching load that she is expected to fulfill. Depending on how much of a faculty appointment is tied to the research institute, determines the teaching load for a faculty member.

Dr. Slate described how the department has three major sets of faculty. He and three other faculty hold full-time appointments tied to the department. Slate reported that

the majority of faculty in the department hold quarter-time appointments at the research institute. Then, the other set of faculty hold a primary appointment with the research institute and a small appointment within the department. Dr. Sandstone stated that he holds a quarter-time appointment at the research institute. He typically teaches three and occasionally four courses per year. The undergraduate courses that Sandstone teaches are for upper division students. Sandstone reported that those faculty who have three-quarter of their appointments through the research institute will teach only course per year and that course will be "something very, very specialized."

All three faculty interviewed reported that these different type of appointments equate to the department holding different expectations for a given faculty member's teaching. Dr. Sandstone indicated that for those faculty with larger research appointments, "teaching may not be that important or evaluated as stringently as those that are dominantly teaching faculty." Dr. Slate corroborated that for those faculty with more of their appointment at the research institute, commitment to teaching "weighs very little" in decisions related to merit, promotion, and tenure. Dr. Sandstone stated that while teaching is "certainly a very valued part of all of our appointments," it is difficult to understand how it is evaluated effectively. He reported that faculty in the department share a skepticism about student evaluations. However, student evaluations are the only metric the department has to measure effective teaching. Dr. Galena stated that she has received advice cautioning her to spend less time on her teaching in order to focus on her research. In conversations with new faculty in other departments, she has learned that this

advice is consistent across the institution. However, she reported that other departments seem to have more equitably teaching loads, particularly for newer faculty.

In addition to the divisions in the department related to their appointment structure, Dr. Slate observed that the department has a disciplinary divide. He reported that the department could be described as, "We've got geophysicists and [then] everybody else." Slate observed that geophysicists see things differently. He stated that these faculty view things in terms of physics and equations. He reported that the physical proximity between faculty offices exasperates these differences. Those faculty who have primary appointments with the research institute are assigned offices in a different building which is a half mile away from others in the department. For this reason, Slate observed that casual conversations run along these disciplinary divides based on who "you're likely to bump into." Dr. Galena also observed that few in the department prop their doors open which mitigates casual conversations from happening very often. In addition, Slate reported that those who have primary appointments with the research institute may not teach any undergraduate courses. These faculty may not be as engaged or interested in discussing undergraduate curriculum or teaching either at department meetings or in casual conversations. Dr. Sandstone reported that they rarely discuss undergraduate curriculum at the monthly department meetings. The focus for the Traveling workshop on undergraduate programming was not typical. Sandstone observed the department had only focused that intently on undergraduate curriculum a few times over the last twenty years.

Dr. Sandstone regularly team-teaches a course with a colleague. He and the other instructor collaborate mainly on the keeping the content of the course current rather than pedagogy. Dr. Slate reported how he has team-taught several courses with other faculty. What he most appreciated about team teaching was the opportunity to collaborate with another instructor on teaching. He and the other instructor will observe each other teaching and take note on what teaching strategies best engage and help students learn. He stated that in these situations "it's not simply alternating who is speaking, but literally, trying to serve as a team with regards to what students are getting at any given moment." He finds these interactions highly satisfying. However, Slate noted than outside of team-teaching, those type of conversations about teaching do not happen very often. Dr. Galena corroborated. She observed, "I like my department, I like the people in it. I think they're all really nice people, and yet we don't necessarily talk all that much."

Chapter 5: Cross-Case Findings

  The cross-case findings presented in this chapter are the result of an iterative analysis process used across the collected data. The process aimed to build an understanding of the patterns that emerged within specific sites and across multiple sites. The analysis sought to develop an understanding for how faculty adoption of active learning pedagogies operated in these different settings. The data analysis included interview transcripts and documents related to each site. In addition, key informant interviews were used to identify rival explanations or corroborate interpretations. The findings are organized by the themes that emerged. Where applicable, key informant perspectives are included with the particular theme. This chapter will discuss these themes.

Factors Perceived by Faculty as Influencing Improvements in Teaching

  Table 5.1 summarizes the findings related to the cross-site analysis. The factors listed in the table emerged from the analysis of interview transcripts and (where applicable) department or institution related documents. The table uses symbols to denote how the given factor was perceived by faculty at the site. When the faculty interviewed for that site perceived the given factor as a positive influence to improving their teaching practice, it is denoted with a plus sign. When faculty interviewed for the given site perceived the factor as a negative influence toward improvements in teaching, it is denoted with a negative or dash sign. For those sites where the factor was discussed but where faculty perceptions were neutral as to whether it had any influence, a zero denotes the neutrality of the factor. Finally, as each site is unique, not all factors were reported by

faculty as applicable to their specific sites. If a factor was not present, the factors is noted

as N.R. to denote no response for that particular factor. A discussion by these themes

follows.

Table 5.1

Factors perceived as influencing improvements in teaching

	Jasper	Gabbro	Olivine	Copper	Marble	Granite
Highest degree awarded by department	M.S.	M.S.	Ph.D.	B.S.	B.S.	Ph.D.
Communications related to teaching are valued and occur regularly among the majority of department.	+	+	+	+	—	—
Large enrollment introductory/general education courses are a source of sharing about teaching.	+	+	+	+	—	—
Large enrollment introductory/general education courses prompt *multiple* active learning pedagogies.	+	+	+	+	N.R.	N.R.
Large enrollment introductory / general education courses motivate use of classroom responses systems.	+	+	+	N.R.	+	N.R.
Large enrollment introductory / general education class configuration allows for range of active learning.	+	—	—	—	—	—
Addressing the needs of teacher preparation fosters departmental collaboration.	+	+	N.R.	N.R.	—	N.R.
Language of educational research is viewed as a challenge and knowledge is viewed as critical in program-level changes.	+	+	+	N.R.	N.R.	N.R.
Departmental expectations: Excellence in teaching is viewed as a departmental norm.	+	+	—	+	+	—
Teaching is highly valued when department considers **faculty hires**	+	+	N.R.	+	N.R.	—
Decision-making processes were characterized as reflecting high levels of mutual respect	+	+	+	+	—	—
Incentivized teaching: Faculty share an understanding that teaching is highly valued in **metrics related to merit.**	—	+	—	—	—	—
Student evaluations are factored in ways that allow for risk taking in teaching	0	—	—	—	—	—
Teaching load allows for as much innovation in teaching as faculty perceive is needed	—	—	0	—	—	—
Sufficient **time is given for reflection** and innovation related to teaching	—	—	—	N.R.	N.R.	N.R.
Peer evaluations of teaching is highly valued as an opportunity to help both observer and those observed.	+	+	0	+	—	N.R.
Goals for deeper student learning encourage active learning strategies	+	+	+	+	+	+
Institutional Support: Teaching awards are recognized as significant	N.R.	0	0	N.R.	0	0
Support for technology in lecture classrooms encourages active learning approaches	+	N.R.	—	+	+	+
Institutional **faculty development** is viewed as positive influence in improved teaching.	—	+	—	—	0	+
National geoscience-related faculty development is viewed as positive influence in in improved teaching.	+	+	+	+	+	—
Early Career workshop participants	Y	Y	Y	Y	N	N
Traveling workshop held at department	Y	Y	N	N	Y	Y

Communications Related to Teaching

At four settings (Jasper State, Southern Gabbro, Olivine, and Copper State), faculty reported the value of conversations with colleagues about teaching practices. These conversations happened in hallways, during lunch, or over a late afternoon beer. Faculty at these sites described how teaching-related conversations began from an area of common ground which could be pedagogical or disciplinary.

In contrast, at University of Granite, the physical distance between faculty offices limited interactions. Those faculty who hold joint appointments with a research institute occupy offices in a building located about a half mile from the departmental building. Dr. Galena noted that overall there is not a "strong social feeling." When she first started in the department, a retired faculty member thanked her for "joining the open-door club" because so few people propped their doors open. Galena likes all her departmental colleagues. However, she stated that they rarely talk with each other outside of the one-hour, monthly department meeting. Dr. Slate attributed the limited conversations to the fact that so few faculty in the department teach undergraduate courses. Slate stated that he values opportunities to co-teach with colleagues. Under co-teaching circumstances, he has learned multiple ways of approaching teaching. He reported that the department has few courses where co-teaching is used.

Large Enrollment Introductory / General Education Courses

Source of departmental sharing about teaching. At Jasper State, Southern Gabbro, Olivine, and Copper State, the challenge of large enrollment courses was perceived as a shared experience that served to unite the faculty who taught those

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courses. Faculty reported how they benefitted from sharing teaching ideas with the other faculty who taught the large enrollment courses. Across all settings, faculty discussed their experiences teaching large enrollment introductory or general education courses. Teaching these courses is considered part of faculty "service" to their institution. However, sites made different decisions as to who in the department taught these courses. At Jasper State, Southern Gabbro, Olivine, and Copper State, tenured faculty at all position levels teach introductory courses. In a single academic term, multiple faculty are assigned to teach the same large enrollment course. Their shared experience became a common source of informal sharing about teaching at these sites.

Through the shared experience of these large enrollment courses, faculty share different pedagogical approaches, specific teaching activities, classroom management techniques, or assessment strategies. At Copper State, Dr. Malachite reported that, "For teaching intro, we've shared a lot of ideas." She described how they may share approaches for engaging students in learning about a specific concept, ways to use technology in the classroom, or strategies for grading student work. Dr. Feldspar at University of Olivine described how the department collaborated on a large, common test bank of assessment questions to use for the large introductory courses. Dr. Limestone at Southern Gabbro described how an idea for a paper-based response system became widely adopted by the faculty teaching introductory courses. Dr. Gypsum noted the strong collaboration at Southern Gabbro among the three or four who are teaching the course at any given time. At Jasper State, both Dr. Mica and Dr. Talc described in detail the range of active learning strategies incorporated into the large enrollment general

education courses. Dr. Obsidian noted the two-way flow of teaching ideas among the department because of the innovations in these large enrollment classes at Jasper State. Obsidian reported that "there's been a lot of emphasis on teaching methods, and it's been a very exciting thing to watch and to hear about and occasionally to incorporate into my classes."

In contrast, at Greater Marble Dr. Shale noted that tenured faculty are known to "actively work to move away from teaching general education classes." Dr. Quartz indicated that he was trying to transition away from general education courses to smaller honors courses. Dr. Shale and Dr. Pyrite noted that discussions related to these courses are a source of tension within the department. There are strong opinions about who teaches these courses and how the courses are taught. Dr. Pyrite reported his concern about the department approach to these courses:

> . . . *There's a fight about how intro classes are done, and in the end, what we've done is something that I think is not so smart. We've basically hired some people with just master's degrees who are teaching the intro courses. So, we don't have the faculty that are active in research in many of those courses. I think it's probably not such a smart thing. It's not such a great college experience for the students. . .*

At the University of Granite, over three-quarters of the faculty have some fraction of their appointment at an affiliated research institute. Therefore, only a few of the tenured or tenure-track faculty teach large introductory courses. One of the introductory courses is split into modules where three faculty regularly teach topics within their specialty areas. Within that single course, each of the three faculty provides a separate syllabus. Dr. Sandstone reported that team teaching is used as a means of assigning

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faculty with the specific disciplinary expertise. Co-teaching assists faculty by allowing

them to teach in their chosen field, rather than preparing course materials outside of their

expertise.

Motivates use of active learning approaches. At all settings faculty described

ways that they engaged students in the large enrollment courses through active learning

strategies. Faculty expressed a commitment to engage students through active

pedagogical techniques. This commitment motivated faculty at many of the sites to

experiment and adopt different teaching strategies. Dr. Galena at Granite reported about

her introductory course that "[y]ou just can't expect students to sit there for an hour and a

half just listening and taking notes." All three Olivine faculty identified these large

enrollment introductory courses as the most fulfilling. Dr. Current described his large

enrollment (260 students) introductory course on climate change as challenging and

rewarding. He noted that, "students get very passionate, I get very passionate, and really

come out of this class totally energized."

At multiple sites, faculty described the many different active learning strategies

they used with the large enrollment courses. These approaches included collaborative

exams, small group collaborative problem solving, and think, pairs, share strategies for

learning critical concepts. At Jasper State, Dr. Mica stated that before she started

incorporated active learning strategies:

> *I would walk around . . . I would ask lot of questions, and students would interact*
> *with me, but it's out of a room of 150. It's the same 10 students all the time. Doing*
> *the think, pair, shares, it just gets people engaged more, and I can tell that it helps*
> *their learning.*

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Motivates use of classroom responses system. At multiple sites, faculty reported use of some type of classroom response system (either electronically or using paper) to formatively assess students, to break up the lecture, and to maintain student engagement. For example, at the University of Olivine, all three faculty stated ways that they had used "clickers" as just one strategy for the large enrollment courses. Dr. Feldspar expressed frustration with the technological sloppiness of using "clickers." Initially, he finds that students are less comfortable with active learning strategies. However, as the course progresses, it "organically drifts towards active because by then, the students don't fear each other." At Southern Gabbro, Dr. Limestone described how all the faculty had adopted using "manual clickers" through the use of colored ABCD cards with the large enrollment courses. He stated how he:

> *started to use the cards, and practicing with them, and getting better, and realized that the student reaction, the dynamic in the classroom is so great when you do that. It promotes instant conversation. . . . I had to explain the value of these things to the rest of the department.*

Configuration of classrooms deters active learning strategies. Faculty expressed frustration about classroom configuration for these large enrollment courses at nearly all of the sites. Both Dr. Limestone at Southern Gabbro and Dr. Current at University of Olivine described the lengths they went to experiment with small group learning despite the configuration limitations. Dr. Limestone described how he numbered the theater seating as a logistical strategy. Limestone observed that no one else was willing to spend that much time on logistics. Dr. Current used small group strategies for collaborative exams. Dr. Current believes that even in the large enrollments:

it's got to be interactive. The students have got to participate. That's so important, and it frustrates me at my own university, because we're still building lecture theaters, which cater to the big classroom; they [the faculty] just stand there lecturing. Not building more interactive flexible rooms.

At University of Granite both Dr. Galena and Dr. Slate described the challenges of integrating hands-on exercises in an auditorium setting. Galena reported that with enrollment of 65 students, she could still incorporate activities that involved grouping students in clusters of four or five. However, when enrollment gets larger than 65 students, the logistics in the auditorium setting are prohibitive of allowing small group pedagogies.

In contrast, faculty at Jasper State described two strategies for addressing the issue of classroom configuration. Dr. Mica and Dr. Talc reported how the department pursued and was awarded funding to renovate a classic classroom to a SCALE-UP-style classroom (Student-Centered Activities for Large Enrollment Undergraduate Programs). The new configuration allowed them to incorporate more active pedagogy. In another example described by all faculty interviewed at Jasper State, the faculty embraced the challenge of the theater setting. Dr. Mica described how they collaborated to experiment with pedagogies for 150 students in a theater setting. Then, they scaled up these active learning approaches to a theater setting of over 700 students. Dr. Mica stated that "There's a lot of brainstorming about, okay, we have this idea for an activity in class, can we do that with 700 students?" She also reported that while she had been "scared out of [her] mind," the reviews for the course by students were positive.

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Key informant perspectives related to large enrollment general education/introductory courses. Several key informants were not surprised that general education/introductory courses acted as focal points for sharing about teaching. One key informant viewed shared teaching assignments as a means of spreading new ideas about teaching across departmental teaching practices. Another key informant wondered if actions by the chair motivated departmental colleagues to share ideas about teaching, rather than simply the shared assignment of large enrollment courses. Dr. Garnet, who teaches at a small liberal arts college, perceived that this finding may be more present at larger institutions. In her department, colleagues discuss teaching related to a variety of courses. However, from her involvement in the Early Career workshops she has understood that teaching large enrollment general education courses "become a shared experience, so then a way to launch a conversation related to teaching." Dr. Beryl, who had taught at a research university, expected that faculty would need peers or an environment that promotes the use of different teaching methods to support their adoption and effective use of new teaching approaches. He viewed the shared teaching of large enrollment courses as a kind of mechanism to foster improved teaching. Beryl understood that shared teaching assignments could spread new teaching ideas between colleagues. Where these shared assignments can be found within the department or within the campus, "there's a much greater chance of success of actually reaching a critical mass to have more people involved." Dr. Howlite, who teaches at a large research university, was puzzled by this pattern because his department rarely discussed teaching issues. His institution used to rotate the assignment of large general education courses. However, the

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teaching "delivery was very uneven." When the department observed that more students wanted to take courses from specific instructors, the department decided to have a model with fewer people involved. Howlite would have attributed the increase in conversations and sharing about teaching to actions by the chair. The ways teaching assignments were shared would have been determined by the chair. Howlite thought that "how effectively he or she [the chair] communicates institutional expectations, and yet nurtures and support faculty through the system, I think plays a big role." While an in-depth study of departmental leadership was outside of the scope of this study, two settings identified the positive role of departmental chairs. Faculty interviewed at University of Olivine and Copper State specifically reported how their department chairs valued excellence in teaching.

Key informants suggested that the way a department managed teaching assignments for introductory and general education courses could be indicative of how the department prioritized their role in increasing the scientific literacy of students outside of science majors. At Dr. Howlite's institution, a concern for quality instruction led to reducing the number of faculty who teach these courses. Dr. Agate noted that these courses can be challenging to teach both pedagogically and from other issues that arise such as academic honesty and attendance. She observed that because these courses present common challenges, faculty also find them easier to discuss with colleagues. Dr. Peridot expressed concern for her own department's approach to assigning general education courses to lecturers who do not have access or time for faculty development.

Teacher Preparation Courses Foster Collaboration about Teaching

All sites offered an undergraduate degree in support of teacher preparation. Several sites described how addressing the learning needs of future teachers promoted greater awareness of active learning pedagogies. At Southern Gabbro and Greater Marble some faculty hold joint appointments in a science education program outside the department. At Southern Gabbro, faculty reported the value they placed in having colleagues with these joint appointments who readily shared their pedagogical knowledge with the department. At Greater Marble, the faculty member who held the joint appointment reported high levels of sharing with other colleagues who taught the teacher preparation courses. However, another faculty member at Greater Marble noted the capped enrollment of these courses as a teaching load inequity. He stated:

> *It always amazes me that for some reason their classes are only 20 but the rest of us are teaching 30 to 100 and they're getting the teaching awards. Part of it, it's like a lot easier to do more innovative stuff in a small class. . .*

Key informant perspectives related to teacher preparation courses. Dr. Peridot, who is particularly knowledgeable about teacher preparation programs, was surprised that the faculty interviewed had not described teacher preparation courses as more of a burden. From her experience, faculty who teach science education feel a heavy obligation to inform their departmental colleagues about improved teaching approaches. She noted that faculty who teach science education, "have this hidden agenda to spread that kind of teaching to all of the courses."

Language of Educational Research Viewed As Challenge

The language used by educational research was perceived as a challenge by faculty at multiple settings. At Olivine University faculty described frustrations regarding the language of educational research, which became a barrier to their pursuit of improved teaching. Dr. Feldspar expressed his feelings of alienation related to the terminology used by educational researchers at a workshop sponsored by a leading national association concerned with undergraduate education. He stated:

> *I'm sure these are nice awesome people behind this, but I found that one[workshop to be one] of the more off-putting and alienating [events] and I found myself angry at the end of the day. What I found that pushed me there often times is the jargon because jargon by its nature is exclusionary. It's like the jargon of the surfer would be foreign to me so it makes me not want to hang out with surfers, but jargon of educators is so off-putting to me.*

Feldspar noted that his department had a similar negative experience when Olivine brought in external assessment experts. Faculty in the department had wanted to discuss and deliberate over the different pedagogical assessment strategies. However, Feldspar noted that rather than being allowed any departmental ownership, "We were talked at and we were given a bunch of complex jargon." Dr. Epidote reported similar frustration at not being funded for a proposal that aimed to improve geoscience education at Olivine. She reported that the proposal was well received but was not funded "because it didn't have the right lingo." At Jasper State, Dr. Talc recognized learning the language of a educational research as a challenge he wanted to pursuit. He wrote a proposal and was awarded a grant that enabled him to work with science education specialists on improved teaching approaches. He credits the grant as critical in gaining credence from

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administrators for his teaching ideas. At Southern Gabbro, Dr. Limestone stated the advantage that his department had in already understanding pedagogical and curricular reform prior to the Traveling Workshop. He reported, "If we were a department that had never talked about assessment or the value of pedagogy . . . It would have seemed overwhelming."

Departmental Expectations toward Improved Teaching

The study sought to understand faculty perceptions about how departmental context, including departmental norms, influenced decisions about adopting active learning pedagogy. Faculty across all settings characterized different ways that they came to understand departmental expectations about improved teaching. Faculty described these expectations in connection with hiring practices and metrics related to tenure and merit. They described what they knew about their departmental colleagues' teaching and how they learned about their colleagues' practices. They situated expectations within their assigned teaching loads and the teaching loads of their peers. In addition, faculty described to what extent colleagues discussed teaching within the department. They characterized the nature of these discussions and the dynamics of the departmental interactions.

Teaching is highly valued when departments consider faculty hires. At multiple sites, faculty described high departmental expectations regarding excellence in teaching. At Jasper State, Southern Gabbro, and Copper State, these expectation begin with and are perpetuated by the hiring process. The hiring process initiates the first conversations

about teaching with the candidates. These conversations and expectations persist as the newly hired faculty assume professional responsibilities.

At Jasper State, Dr. Obsidian reported that every faculty member hired in the last ten years has demonstrated excellence in teaching. He stated that all their hires have been by consensus. They have never had "drawn out problems with people with different views." Dr. Mica stated that newer faculty were also hired with an expectation that research would be a significant portion of their profession. She also noted that the department sends new hires to national geoscience teaching workshops. Dr. Mica stated that ""[t]he department very much has a culture of thinking about pedagogy and valuing [it]." Despite a greater emphasis on research with recent hires, Dr. Obsidian reported that "The new faculty have been the leaders in moving away from the traditional lecture mode in their classes. So there's a lot more emphasis in small group discussions within the class. . ." He corroborated that the department encourages new faculty to participate in the national geoscience teaching workshops. In addition, Obsidian stated that members of the department are heavy consumers of the teaching activities found on websites associated with these workshops. Both Dr. Mica and Dr. Talc pointed to the education research- related grants as emblematic of the departmental expectations toward excellence in teaching. New faculty hires are made aware of the department's involvement in these grants. Talc reported that "[w]e always valued those kind of interactions and accomplishments. We've pointed at them repeatedly with pride. . ."

Southern Gabbro reported similar perceptions related to how the department valued teaching in their hiring and professional development. Dr. Basalt and Dr.

Limestone at Southern Gabbro both described how critical the candidate's understanding and use of effective pedagogy is in the hiring process. Basalt described the teaching observation process the department uses for interview candidates. Limestone stated that

> *I am proud to say that it's [teaching is] really highly valued, both in the initial hiring process, even in the--yeah, I guess that's part of the hiring process--when we solicit applications for new faculty, we ask for basically a teaching philosophy statement. So we not only expect them to be able to write about their research and how they will move on with their research if they're hired at [Southern Gabbro], but we actually ask about their teaching philosophy and how they see their teaching as fitting in.*

Limestone and Gypsum also indicated that the department's stance toward faculty development is illustrative of their expectations. As a newer faculty member, Dr. Gypsum situated his participation in the Early Career workshop with what he had learned about teaching from his department. From the workshop he learned many new approaches that he uses in his courses every day. He also noted the value of participating in the workshop as a third-year assistant professor. At that time, he had two years of experience with teaching. He had already come to understand the teaching expectations and what the position entailed. Gypsum credits his colleagues for influencing his learning about pedagogy, particularly Dr. Limestone.

At Copper State, Dr. Malachite stated that the institution has "retained a strong teaching intensive philosophy" from its history as a Teachers' college. She noted that the department makes "it very, very clear" what the teaching expectations are when hiring new faculty. Dr. Gneiss stated how shortly after he was hired, he received significant support for a teaching idea. Gneiss had identified a need for equipment that was

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necessary in order to teach students how to collect geophysics data. He stated that he "didn't have to write an NSF grant. I didn't have to start publishing papers on near-surface geophysics. I just told the dean and my department chair, 'We need this stuff. . ." Malachite and Gneiss also noted the department's support for the Early Career workshop for faculty new to the department. Malachite stated that since she was hired, every other faculty hire has participated in the Early Career workshop. Gneiss stated that he always recommends that his new colleagues participate in the Early Career workshop. As a new faculty member, Dr. Adamite described how departmental colleagues shared relevant teaching resources with her for one of her assigned courses. She was hired to teach a particular course with the understanding that she would bring her knowledge of tectonics to students' understanding of earth history. She had never taught or even taken an earth history course. Because colleagues readily supported her with materials, she was able to add more hands-on activities.

Decision-making processes were characterized as reflecting high levels of mutual respect. At multiple sites, faculty described how the department positively regarded differences in philosophies and contributions. Faculty perceived this stance of mutual respect as critical in guiding productive decision-making processes. At these sites faculty described the ways that departmental colleagues worked through philosophical and other types of differences to reach a shared mission toward teaching.

In contrast, at two sites faculty described departmental decision-making processes and interactions related to teaching differently. At Greater Marble, Dr. Stratus was the only faculty interviewed who described positive interactions with colleagues surrounding

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pedagogic concerns. He stated how he exchanged ideas and traded solutions to pedagogical problems with colleagues who instructed in the pre-service teacher courses. The other faculty interviewed noted that departmental colleagues rarely discussed teaching. Moreover, they described departmental decision-making processes related to pedagogic and curricular concerns as strained. Both Dr. Pyrite and Dr. Shale looked outside the department to share ideas about teaching either through workshops or colleagues at other institutions who shared similar teaching concerns. Departmental discussions related to teaching issues were perceived as somewhat adversarial. Dr. Quartz attributes some of the strained relations to curricular discussions occurring over the last five years. The department has maintained the same traditional curriculum for the last fifty years. He noted that to bring about change as a department "was a huge struggle, to try and navigate those waters." He noted that "the path forward wasn't very clear" for all faculty members. In comparison, at University of Granite, faculty describe interactions as cordial but efficient. Dr. Galena indicated that departmental decision making is "absolutely not combative." She noted that:

> *It's more of a sense of . . . how can we get things done with most people not doing anything at all. We're all doing so much work all the time that we just don't want to be adding anything else to our plate.*

Dr. Sandstone reported that the type of curricular and pedagogical discussions held at the Granite Traveling workshop "happen. . .very rarely." He stated that in his many years in the department those type of discussions are "few and far between." He has appointments at other institutions, but noted that Granite is "actually one of the more pleasant places." At Granite, Dr. Slate noted that the department tolerates differences in teaching

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philosophies. At Greater Marble, Dr. Pyrite stated that the department does not welcome minority voices.

At sites where faculty reported greater collaboration and communication surrounding improved teaching, differences were also a factor. However, at these sites, faculty described ways that the department negotiated decisions while recognizing variation in approaches. At multiple sites, faculty described how attention to the needs of their students framed the department's ability to move forward in the face of strong, differing opinions. Some faculty reported peer observations as a means for understanding the different ways that their colleagues approached improved teaching. Decision-making processes were characterized as reflecting high levels of mutual respect among department members. At University of Olivine, both Dr. Current and Dr. Epidote described in positive terms the structure and way the department reached decisions. Dr. Current described the department as "very much like socialist collectives, everyone's got to talk; it's not a dictatorship." At Jasper State, Dr. Mica reported how different department members are valued as leaders in different areas of expertise. These leaders spearhead issues related to their particular focal points but in the end it is the department as a whole that makes decisions. Dr. Basalt at Southern Gabbro described how the department excels at making decisions as a group. She attributes their ability to work well together toward shared goals. At Copper State, in comparison with the other faculty interviewed, Dr. Gneiss reported talking less frequently about pedagogy and more about classroom management with colleagues. He stated that his teaching approaches and teaching interests were different from others in the department. Nevertheless, he stated

that "one of the reasons why I'm happy in my department is . . . I think my colleagues generally respect what I've done and what I've brought to the table . . ."

Sites that characterized productive decision-making processes also reported how the department had tackled department-wide curricular or pedagogic concerns. At Southern Gabbro, Dr. Limestone described how the department was faced with institutional pressures to focus on program assessment. He reported how they discussed the institutional mandate and decided to use it as an opportunity to make their programs better. Dr. Basalt also described these circumstances. She stated that the department had "an awesome time when we developed a matrix for our outcomes assessment for our department." At Jasper State, faculty described how institutional pressures related to low enrollment motivated new approaches for integrating curriculum and reducing programs. Dr. Obsidian recalls how those pressures coincided with everyone receiving a 15% salary reduction. He stated that those in the department asked "How do we take this opportunity to really build a stronger department?"

Key informant perspectives related to decision-making processes surrounding pedagogic and curricular concerns. In reviewing the findings related to how departments employed decision-making processes, key informants offered different hypotheses for why departments experience difficulties in negotiating their differences. Dr. Howlite listed three areas that he attributed to difficulties related to departmental relations. His observations originated from his experiences conducting departmental reviews and as a facilitator for traveling workshops. First, he hypothesized that the effectiveness of the chair predicted how departments reached decisions. Second, he

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observed greater difficulties where departments allowed differing types of appointments between teaching and research. He noted that, "[d]ifferent expectations for faculty lead often times to a disinterest of the research faculty on what was going on in the teaching or at least not being very engaged in what other faculty did with teaching." Third, both he and Dr. Peridot hypothesized that a divide between older and younger faculty could contribute to challenging department dynamics. Howlite observed that younger faculty were more eager for changes in teaching. Dr. Peridot also wondered whether an age division contributed more to faculty perceptions surrounding teaching practices in climate and environmental science. Peridot noted that more recent faculty often included those in the fields of climate and environmental science.

The age gap as understood by Peridot and Howlite was reported at a few of the settings studied. At Copper State, the three faculty interviewed were more junior (3 to 8 years of teaching). Yet, none of the faculty alluded to any differences in their colleagues teaching related to years of teaching. Dr. Gneiss at Copper State remarked on the support from senior members of the department and the department chair in promoting Gneiss' ideas about teaching. At Jasper State, Dr. Mica (9 years of teaching) observed a division between faculty more recently hired and those with longer tenures. Dr. Obsidian (27 years of teaching) remarked that younger faculty were leaders in adopting new approaches to teaching. He described the work of these newer faculty with enthusiasm and noted their innovations as a source for departmental socialization related to teaching. At University of Olivine, Dr. Current admitted that he occasionally wondered whether the most senior faculty saw the point in active learning pedagogy. In the same response,

Current also noted how the department chair "understands the value of excellent teaching and active and collaborative learning."

Incentivizing Teaching

Faculty perceived few extrinsic rewards and few institutional incentives for adopting active learning pedagogies. At multiple sites faculty reported dissatisfaction with the ways teaching was recognized in relation to merit decisions. In addition, heavy teaching loads compromised their ability to observe the teaching of peers or to reflect on their own practices.

Departmental Metrics related to tenure, promotion, and merit increases. Metrics related to tenure, promotion, and merit increases are one way faculty come to understand institutional expectations about teaching. All faculty discussed these metrics in terms of a tri-partite approach to evaluating contributions for teaching, scholarship, and service. However, with regard to the six sites covered by this study, faculty at Southern Gabbro were the only faculty who agreed that teaching was highly valued in departmental and institutional metrics. At sites like Copper State and Greater Marble the faculty interviewed disagreed with each other as to how much teaching factored into merit decisions. At Jasper State, Olivine, and Granite, faculty shared an understanding that teaching was not valued as highly as research scholarship in such metrics.

Decisions about teaching strategies related to student evaluations. Many of the sites described how the institution used student course evaluation data as a measure of teaching contributions for the purpose of merit evaluation, promotion, or tenure. Even at Southern Gabbro, the site where all the faculty interviewed described teaching as highly

valued in the merit, promotion, and tenure reviews, faculty expressed frustrations about whether student course evaluations were a useful tool. As a means of gathering more constructive student input related to learning, Dr. Gypsum incorporates "minute paper" strategies at several points throughout the term. Dr. Basalt reported how course evaluations discouraged innovative teaching because of the importance placed on them: "That is the culture of our institution, the student evaluations are important."

Faculty at multiple sites reported how student evaluations limited incentive to innovate in teaching. At Southern Gabbro, Dr. Basalt reported this story about a colleague:

> *He just decided to completely restructure his classes to incorporate more active learning and flipped classroom. He put so much time and energy into it and the students hated it. The student evaluations were just utterly terribly and so he was so upset. At the end he's like, why am I bothering? So, I would say the barriers are time and maybe fear of experimenting and failing.*

At University of Olivine, Dr. Feldspar observes students' affect toward active learning. He adjusts his pedagogical strategies to ensure that students are not inadvertently alienated by the approach. He reported that at times, "You just almost sort of see them withdraw into their shells and groan." Feldspar stated that students widely complain about some of the strategies on social media. Dr. Epidote who had recently gone through tenure at Olivine noted adequate teaching is judged by course evaluations and that "quite frankly, the only people that bother to take the time to do it, are the students that really, really like you, and the students that really, really hate you." At Copper State, Dr. Gneiss expressed similar frustrations:

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If I'm being cynical, the last thing you want to do is be really hard, or try something that the students are unfamiliar with, because your ratings will go. I mean, there are obviously people that are willing to try it anyway, but everybody knows it's a risk. There's one particular faculty member in our department that always points this out. The easiest way to get five out of five is to be really, really easy, and don't make the students do anything.

Key informant perspectives related to student evaluations and merit metrics.

The key informants expected that research would be valued over teaching in merit metrics but expressed concern that student evaluations may inhibit adoption of active learning pedagogies. Dr. Peridot reported that even though her institution valued teaching more than research, teaching was measured mainly through student evaluations. She stated that "I think that is a terrible truth that seems to be fairly consistent everywhere I've been." She described how institutions value teaching based more on the number of classes you teach "and the students that you churn through." Dr. Beryl had understood that more institutions were taking teaching into consideration in merit decisions. He wondered if student evaluations were the chosen measurement because "most people like to reduce things to a number. And it's hard to put a number on your teaching. . ." He observed that most administrators understood that the student evaluation number was "pretty meaningless." Dr. Howlite wondered if faculty were apprehensive about adopting active learning pedagogies because it takes time to effectively learn how to employ these practices. Once practices are effectively employed, Howlite "would be willing to bet dollars to doughnuts that if you teach an engaged classroom, your course evaluations will be better and more positive."

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Teaching loads, availability of time to reflect on teaching, and opportunities for peer evaluation. How faculty understood their teaching load as part of their professional work factored into their ability to make teaching improvements, such as adopting active learning strategies. Faculty noted that their capacity to reflect on their current practices also factored into their ability to make improvements. How each department managed teaching loads varied by site. Faculty situated their teaching load and their capacity to make changes within their understanding about expectations for promotion, tenure, and merit increases.

At Jasper State, teaching assignments and requirements for service increase following tenure. Dr. Mica admitted that she finds it difficult to continuously improve all of her assigned courses. With the amount of time it takes to make teaching improvements to the large enrollment (over 700 students) course, she lacks the necessary time to reflect and invest in innovating for a new majors-level course she teaches during the same semester. Mica views the high teaching load as her largest barrier to improving teaching. Faculty stated that teaching and research are valued equally in how merit metrics are defined. However, all the faculty interviewed at Jasper State indicated that research is valued more than teaching by the institution.

At Southern Gabbro, Dr. Gypsum reported that all faculty position levels share the same teaching load. As a pre-tenured faculty member, Gypsum identified this common teaching load (4 to 5 courses per year) as a demonstration of the department's commitment to teaching. Limestone and Basalt lamented high teaching loads as a factor preventing faculty from being able to make peer observations more frequent. All three

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faculty commented on the value the department places on observing each other. Basalt reported that she would have difficulty being assigned a large enrollment course and indicated that "it would scare the pants off me." She would want more time to observe others and reflect on her own practices in order to adopt the teaching strategies that would be required for high levels of faculty and student interaction.

At Granite, the teaching load is highly variable depending on the faculty appointment. Dr. Sandstone described how faculty with three-quarter research appointments only teach one class per year and that course would be a highly specialized graduate course. His appointment is partly funded by the research institute so he teaches three courses per year, mainly in upper division courses for undergraduates. Dr. Galena is pre-tenured in a position that is not connected with the research institute. She teaches four courses per year. She would prefer to teach courses for upper level undergraduates or graduate-level courses. However, she teaches large enrollment general education and introductory courses. She devotes one class period mid-semester to gathering student reflections about what is working in the learning environment. However, her ability to make improvements and interact with students in meaningful ways is weighed against her research priorities. She stated that "the advice is basically cut back on the amount of time you spend on teaching so you could fulfill your research obligation."

Decisions about Teaching Strategies Related to Student Learning

Faculty perceived active learning as a means of realizing deeper student learning in their courses. For general education courses, faculty desired students to learn fewer topics more deeply rather than memorizing material. Dr. Current stated that for his

introductory courses he would like students "to have enough knowledge to be a good global citizen who actually understands enough geology to understand the key things." Those faculty who teach climate science described how active learning strategies were helpful in getting students to understand the interconnectedness of the topics. In fields where content is critical for licensure, such as meteorology and geology, faculty discussed the tension between coverage of adequate content and giving students sufficient depth in the subject matter.

Institutional Support for Teaching: Teaching Awards, Technology Support, and Institutional Faculty Development

For all sites, faculty reported ways that their institution demonstrated support for teaching. These examples included teaching awards, technology support, and faculty development. Institutions recognized faculty with annual teaching awards at multiple sites. Faculty expressed indifference or skepticism about these awards. The indifference seemed unrelated to general attitudes about improved teaching. For example, Dr. Basalt at Southern Gabbro commented, ". . . and there are teaching awards, but I don't know if that's what drives decision making on teaching." In contrast, earlier in the interview Basalt had described the importance she placed on her philosophy of teaching. Dr. Shale at Greater Marble University noted that those faculty who teach courses with capped enrollments for teacher preparation receive the majority of teaching awards.

In contrast, faculty perceived technology in lecture classrooms as positive at multiple sites. This technology supported the use of classroom response systems and at one setting in the creation of a "game-ify" activity. Even at Olivine University where the IT support

was not perceived as positively, Dr. Epidote commented that technology had noticeably improved.

In comparison, faculty perception about institutional faculty development varied among sites. When faculty viewed faculty development in service to their specific instructional needs, the activities were perceived as a positive. However, when faculty perceived the institutional faculty development as punitive, then faculty perceived it in a more negative light. At Southern Gabbro, faculty reported positively on how the institution was part of a National Science Foundation project aimed at improving the use of active learning teaching practices across STEM departments. Through this project, the department participated in a professional learning community. Dr. Limestone also commented on the spread of a teaching innovation for large introductory courses that originated out of one of the sponsored workshops. At Olivine University, Dr. Feldspar indicated that the institution requires participation in their workshops for tenure.

National Geoscience-related Faculty Development Opportunities Influence Improved Teaching

At multiple settings, faculty described positive learning experiences associated with national faculty development workshops specific to geoscience. Faculty reported how they valued connecting what they learned about teaching to specific successes or failures in the classroom. At Copper State, Dr. Malachite stated how the geoscience specific workshops were helpful in their specificity to the field. She noted that it was helpful to get feedback such as, "It's too complicated to explain fractional crystallization this way, but it's better if you try it another way."

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Early Career workshop. For the four settings where faculty had participated in an Early Career workshop, all faculty interviewed who had participated in one of these workshops described the high value they placed on the experience. They appreciated how the workshop used a holistic approach that took into consideration the tripartite nature of their appointments. Many described how the workshop gave them a new perspective that they "were not alone" in their new faculty experiences. The ways that the workshop modeled the particular pedagogies was frequently mentioned and contrasted with other less-than-positive faculty development experiences. All faculty described continued, important professional relationships that began at the Early Career workshop. In addition, faculty who had not attended the Early Career workshop acknowledged the value they found in their colleagues' participation. At these sites, the department encouraged early participation in a geoscience teaching-related workshop. The workshop gave the department members a common understanding about balancing teaching, research, and service. In addition, faculty reported that the recent participants infused the department with new ideas about teaching. Faculty at two sites expressed a desire for a similar workshop for faculty once they are awarded tenure.

Traveling workshop. The faculty who participated in the traveling workshop held varied perceptions regarding the workshop and its influence on their pedagogical practices. Both Jasper State and Southern Gabbro described how the timing of the workshop allowed the department to address large departmental concerns in a productive way that led to positive changes. These two sites reported the value they placed on the outside leaders' perspectives for how other departments had addressed similar concerns.

However, it was difficult for either site to directly attribute changes specific to the workshop. At Jasper State, Dr. Talc viewed the influences as more collective and that it is,". . . this continuous pattern of input and changes and responses, and it's hard to point to one thing." At Greater Marble and University of Granite, faculty were in less agreement as to the value of the workshop. Faculty reported at Greater Marble that the traveling workshop "forced everybody to sit down and talk about really difficult issues." However, the extended outcomes of the workshop were characterized as painful. At Granite, Dr. Galena stated that for those "who were already interested in adopting new teaching techniques that [the workshop] inspired them to continue to do that." Dr. Slate recalled that faculty failed to show enthusiasm for the ideas at the workshop. Slate did not see much commitment from faculty following the workshop for any of the ideas.

Key informant perspectives related to Early Career and Traveling workshops.
The key informants attributed the more lasting effects of the Early Career workshops to the intensity of its programming and workshop duration compared to the Traveling workshop. The Early Career workshop lasts five days. In addition, workshop participants remain together through all meals and programming from 7:00 am to nearly 11:00 pm. In contrast, the Traveling workshop lasts one and a half to two days. Traveling workshop participants may eat lunch together but there is no shared evening program. Dr. Howlite observed how participants developed strong ties with each other and with the leaders. Because of the intense nature of the Early Career workshop, Dr. Howlite joked that it could be thought that participants experienced "Stockholm syndrome," as if they were held hostage.

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Key informants also hypothesized other factors which may explain the different effects between the two programs. Dr. Howlite conjectured that the Early Career workshop is focused on the individual and that everyone is interested in their own career and making an investment in it. Dr. Agate stated that most Early Career participants come to the workshop thinking that it will be of high value to them. With the Traveling workshops, Agate noted that some of the department faculty may "be dragged kicking and screaming so the audience is perhaps different."

Key informants reported observations related to how department dynamics influenced the effects of the Traveling workshop. Howlite stated that applications that appeared to reflect some departmental dysfunction were unlikely to be accepted into the program. However, Howlite stated that "about half the time, we get there and find that their biggest issue is something that has never been written down." Dr. Beryl wondered if faculty at Early Career workshops feel that they can talk more freely about their teaching and professional life with faculty unconnected to their institution, whereas faculty at Traveling workshops must have these conversations with peers at their institution. In regard to the Traveling workshops Beryl wondered if it:

> *depends a lot on the personalities of the people involved. So I can see where . . ., in some departments, a conversation may not be as easy as others. That may be part of the problem. I don't think that it's a necessary and sufficient condition, but this may influence the outcomes of the workshop.*

Two of the key informants described how the program activities at Early Career workshops may give participants greater confidence in talking about their teaching and their research with colleagues. These informants hypothesized that participants are more

likely to seek conversations with colleagues when they return to their institution. Dr. Agate and Dr. Garnet described the reflection activities that the Early Career workshop employs to help faculty become comfortable in talking with each other about their teaching, research, and professional life. Garnet stated that she routinely hears participants report through workshop surveys and conversations that the workshop gives them confidence in having conversations about teaching. Participants reported that they now feel better able to contribute to discussions surrounding teaching in their department.

Dr. Agate stated that like the Early Career workshop, the Traveling workshop included a reflection component. For each Traveling workshop, participants were asked to reflect on their experiences and generate an action plan. Agate noted that context matters for both Early Career and Traveling workshops. The Early Career workshop focuses on the whole faculty model, situated teaching with research, service, and other professional priorities. The Traveling workshop is intended to focus on the department within the overall institutional context. Facilitators aimed to have participants recognize how intended goals of the department align with the mission of their institution.

Conclusions

In sum, five main patterns emerged from the data. First, faculty at multiple settings reported that informal communications between departmental colleagues provided ideas for active learning approaches, activities, and resources. In these department, large enrollment introductory or general education courses became a source of sharing active learning strategies among departmental colleagues who taught these courses.

Second, departments at multiple settings communicated expectations and values related to teaching when hiring new faculty. The process of hiring a new faculty member included observations of candidate's teaching and collegial discussions about teaching. These departments also encouraged new faculty to participate in faculty development. Faculty viewed the departmental stance on faculty development as emblematic of the value the department placed on teaching.

Third, the decision-making processes for some departments appeared to enable departments to confront and resolve program-level pedagogical or curricular challenges. In these departments, faculty stated that divergent perspectives were welcomed. Faculty described how department meetings allowed adequate time to negotiate and resolve differences in productive ways. In contrast, faculty at another site reported that decision-making processes related to curricular concerns were more adversarial. This department reported divisions related to contentious decision-making processes. At another site, faculty reported few departmental discussions related to curricular or pedagogic concerns. In this department faculty held appointments with varying expectations related to teaching and research. A key informant reported that in departments where faculty hold appointments with varying teaching expectations, faculty appear to be less interested in topics related to undergraduate instruction.

Fourth, faculty reported how the metrics related to tenure, promotion, and merit inhibited risk taking in teaching. All the sites stated that student evaluations were used to measure faculty teaching. Faculty at multiple sites described how they weighed decisions about whether to adopt a new teaching approach. Faculty reported that new approaches

could have a negative influence on student evaluation surveys. Even if the department highly valued teaching, faculty reported that student evaluations constrained their adoption of new pedagogy.

Finally, faculty described the role of faculty development in influencing their teaching practices. All faculty who participated in Early Career workshops reported the persistent influence this workshop had on their teaching practice and networks of colleagues. Faculty expressed different opinions as to the effectiveness of the Traveling workshop. Key informants hypothesized that the intensity of the Early Career workshop program attributed to its lasting effects. Key informants also noted how the Early Career focused on the individual faculty member's professional life. In contrast, the Traveling workshop focused on department-level goals related to undergraduate instruction. Key informants hypothesized that the effectiveness of the Traveling workshop may depend on wider faculty investment in the workshop goals.

The findings from this study present faculty perceptions about adoption of active learning pedagogies within particular departmental contexts. The cross-case findings reported the themes across these contexts. The themes presented in this chapter, as well as their implications, will be discussed in the next chapter.

Chapter 6: Conclusions

The primary conclusion of this study is that two main factors influenced the degree to which faculty who participated in geoscience faculty development programs reported adoption of active learning pedagogies. These conclusions are:

a) The opportunity to engage in informal, regular conversations with departmental colleagues about teaching promoted adoption of new teaching approaches and ideas.

b) Institutional practices regarding the ways in which teaching practices were typically measured, valued, and incentivized tended to inhibit risk taking in teaching.

In Chapter 4, each of the six unique cases of the study was presented. The cross-case thematic analysis was described in Chapter 5. This chapter discusses the conclusions, the implications for evaluation of faculty development, and recommendations for further research. It is organized into two sections. The first section provides a discussion of the two main factors with subthemes. The final section concludes by describing the implications of these findings for institutional policy, further research, faculty development programs, and the role of evaluation of faculty development. The discussion of implications connects the findings with literature related to change theories and departmental culture reviewed in Chapter 2.

Two Main Factors

Conversations with Departmental Colleagues about Teaching Promoted Adoption of New Teaching Approaches

In this study, certain patterns emerged. These patterns involved faculty conversations regarding pedagogy. The patterns appear unrelated to the type of institution or the highest degree granted by the department. Faculty in these settings described the value of conversations about improved teaching with departmental colleagues. These conversations happened informally, rather than as part of departmental meetings. The teaching ideas that sprang from these regular interactions spread across the department through peer observations, email, and additional hallway interactions. Three sub-themes emerged:

a (1) Common courses that were taught by multiple department members became focal points for teaching conversations.

a (2) In hiring decisions, observations and discussions about a candidate's teaching approach and philosophy were considered.

a (3) In departments where decision-making processes were characterized as reflecting high levels of mutual respect among department members, pedagogical or curricular challenges galvanized the department to embrace and resolve such challenges.

Common courses taught by multiple department members became focal points for teaching conversations. Across all settings in the study, faculty shared experiences related to teaching large enrollment introductory or general education courses. Faculty described how conversations related to teaching often arose from an area of common concern, which could be pedagogical or disciplinary. At all sites studied, the

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challenge of engaging large numbers of students motivated some use of active learning approaches. Teaching these courses is considered part of faculty "service" to their institution. However, departments made different decisions as to who in the department instructed these courses. At departments where tenured faculty at all position levels teach introductory courses, the shared experience of teaching these large enrollment courses became a focal point for faculty sharing related to teaching strategies. At these sites faculty shared how they experimented with multiple active learning strategies in large enrollment courses. Additionally, at one site, faculty described how their ability to scale up active learning strategies to an extremely large enrollment general education course allowed the department more autonomy for determining minimum enrollment for courses in the major.

In addition to large enrollment courses, faculty reported other collective efforts toward undergraduate instruction. At sites where multiple department faculty instructed courses specific to teacher preparation, faculty reported sharing active learning approaches with other instructors of these teacher preparation courses. However, the degree to which ideas were shared with colleagues beyond the teacher preparation instructors varied by site. Co-instruction for other types of courses also allowed faculty to learn active learning approaches from colleagues. Conversely, at some sites, co-teaching was viewed more as a means of bringing multiple disciplinary experts into a single course, rather than an opportunity to share pedagogical strategies.

Lastly, at several sites, faculty described communication challenges related to being versed in the language of educational research. At sites where faculty pursued

pedagogical changes to undergraduate instruction at a program or department-level, faculty reported that inadequate understanding regarding the language of education research posed a potential barrier to change. They described faculty development opportunities where a working knowledge of the language was expected. In addition, faculty perceived the ability to use and understand the vocabulary related to educational research as critical in seeking external funding for program-level curricular changes.

In hiring decisions, observations and discussions about a candidate's teaching approaches and philosophy were considered important. At multiple sites, faculty described how the hiring process inculcated departmental values about effective teaching in new faculty. Candidates were informed about the high expectations for teaching and were expected to discuss their teaching as part of the interview process. In addition, candidates were asked to describe their teaching philosophy in depth. To inform the hiring decision, faculty observed and then discussed candidates' teaching. At one site, despite the institution's heightened focus on research, the dean deferred to the department's decision to select hires based on both teaching and scholarship. Faculty at these sites also described how the value of teaching was demonstrated to newly hired faculty. At multiple sites, newly hired faculty were provided funding and encouraged to participate in faculty development opportunities, such as the Early Career workshop. Faculty described how the department's stance toward geoscience faculty development demonstrated to new faculty the value the department placed on teaching. They reported how new faculty were encouraged to bring back to the department the teaching ideas learned from their workshop experiences.

In departments where decision-making processes were characterized as reflecting high levels of mutual respect among department members, pedagogical or curricular problems galvanized these departments to embrace and resolve such challenges. At these sites, faculty described instances where the department worked together toward addressing a common programmatic, curricular, or pedagogic problem. Challenges arose from institutional policies or initiatives, enrollment concerns, or new pedagogical approaches. The problems faculty described varied across sites. Nevertheless, the manner in which faculty within the departments interacted revealed some common characteristics. Three traits distinguish these departments' interactions.

First, at these sites different perspectives were accepted and valued. Faculty readily shared with the department their ideas about new pedagogies and new course designs. They expected lively discussion. They anticipated questions from their departmental colleagues about how or why the given idea was understood to be an improvement. Faculty acknowledged that their colleagues held a range of philosophies, but many types of contributions were welcome. For example, one faculty member shared how in some geoscience departments, field geologists and quantitative earth scientists view each other's fields with skepticism and even disdain. This faculty member focused his teaching approaches on training students to write computer code as a means of efficiently investigating large datasets, such as the Advanced National Seismic System Earthquake Catalog. He acknowledged that his pedagogical approaches were different from his colleagues who may focus on field observation skills. However, he also reported that the department valued his contributions and supported his ideas.

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Second, faculty at these sites characterized decision-making processes as opportunities where open discussion from all members was sought. When it came to making departmental decisions, they described the structure of their department as non-hierarchical. Faculty noted that the department might have a subcommittee investigate a particular topic. A given faculty member might also be viewed as an expert in a specific areas, such as interdisciplinary learning or undergraduate research. Nevertheless, in the end, the department as a whole deliberated and reached a decision.

Third, faculty described specific strategies employed to mediate conflict within the department. Strong opinions and passion for ideas were expected from department members. Faculty characterized divergent opinions as reflecting the genuine interest colleagues shared in a particular issue. To manage conflict, they described how it was expected that there would be sufficient time for all to weigh in with their perspectives. Faculty acknowledged that unanimous agreement was not always possible, yet it was important to the department to take time to build consensus. By the same token, faculty also acknowledged with frustration the length of time it occasionally took to negotiate decisions when faculty held different teaching philosophies. At these sites, faculty described how colleagues made efforts to concentrate their remarks and interactions on solving the problem. By focusing on the problem, even contentious discussions were described as more productive.

In contrast, at the two sites where faculty characterized decision making and interactions differently, the department rarely undertook department-wide pedagogical or curricular challenges. At these sites faculty noted that few conversations occurred among

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departmental colleagues outside of formal department meetings. At one site, faculty characterized discussions as combative. The department defined governing rules for discussion and voting. This process allowed the department to move forward. Nevertheless, faculty reported that the curricular decision-making processes had caused rifts among colleagues. Faculty at this site reported how they interacted with faculty in other departments, at other institutions, or through faculty development workshops as a means of learning new ideas about teaching or norming their teaching practices with other peers.

At another site, department meetings adhered to strict time constraints and faculty characterized departmental interactions as efficient. Faculty described the role that subcommittees played in addressing problems and formulating solutions. Faculty at this site attributed their limited departmental interactions to offices being at different physical locations. Divisions were exacerbated by faculty holding different types of teaching and research appointments. Faculty with teaching-heavy appointments perceived that those with research-dominant appointments were less invested in undergraduate instruction. Because of these differences, faculty noted that the department rarely tackled department-wide pedagogical or curricular concerns related to undergraduate instruction.

Ways in Which Teaching Was Measured, Valued, and Incentivized Inhibited Risk Taking in Teaching

Faculty at all sites noted few extrinsic incentives toward improved teaching. Faculty described their understanding of the institutional metrics related to tenure, promotion, and merit increases. At only one site did faculty consistently report that

teaching was equally and authentically valued in decisions related to tenure, promotion, and merit increases. Student evaluations were universally employed as a primary metric for evaluating teaching. At multiple sites, both student evaluations and teaching awards were viewed more as a "popularity contest" than a measurement of excellent teaching. Moreover, faculty at multiple sites reported how the reliance on student evaluations limited faculty motivation to take risks in teaching. They reported that some students found active learning strategies uncomfortable. Faculty noted that a number of students favored passive learning approaches that these students found less demanding. At multiple sites, faculty expressed concern that they may not be as effective initially in employing adopting active learning approaches. In turn, student evaluations may decline. Even when strong teaching was highly valued in merit metrics, faculty reported that student evaluations inhibited risk taking in teaching approaches. In addition, faculty described the trade-offs they made balancing teaching loads and research expectations. They described adopting active learning changes incrementally to mitigate negative student evaluations and help balance their professional obligations.

Implications and Conclusions

The conclusions have implications for how faculty share teaching information, how department decision-making processes influence program-level pedagogical and curricular concerns, and how institutions evaluate merit policies related to instructional measures. In addition, the conclusions have significance to faculty development and the role of evaluation in faculty development. The implications for each of these themes will be discussed. The themes will be connected with the literature related to change theories

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and departmental culture reviewed in Chapter 2. Furthermore, recommendations about institutional policy and areas of further study will be discussed.

How Faculty Share Teaching Information

Researchers studying institutional change and change strategies related to undergraduate STEM instruction hypothesize that faculty are more likely to adopt an innovation when opportunities for collegial interaction and support are evident (Kezar, 2011; Henderson & Dancy, 2007; Henderson, Dancy, & Niewiadomska-Bugaj, 2012; Borrego, Froyd, & Hall, 2010). In studies from the fields of physics education and engineering education, faculty report adoption of active learning pedagogies is easier when local role models exist within their department. Both physics and engineering faculty report social interactions with disciplinary peers as the most effective mechanisms for learning about active learning pedagogies (Henderson et al.,2012; Borrego, Froyd, & Hall, 2010). In addition, situated learning theorists argue that learning about teaching is realized through teaching practice over time. These researchers reason that studies should examine the social interactions and context that supports or inhibits learning about teaching (Cobb & Bowers, 1999; Putnam & Borko, 2000; Boud & Walker 1998).

The cross-case findings support the conclusions of the earlier research. In addition, the socialization patterns among geoscience faculty at these sites suggest that having multiple tenure-track faculty instruct large enrollment general education or introductory courses could provide a common experience for fostering the social interactions related to teaching. This finding suggests that college and university administrators should consider the adoption of incentives that would promote strategies

in departments to encourage shared teaching of large enrollment introductory courses. Faculty involvement in the development of such policies would be important. Studies in higher education have demonstrated that top-down institutional change is not as effective for pedagogical reform as more grass roots efforts (Henderson, Beach, & Finkelstein, 2011; Kezar & Eckel, 2002). When faculty lacked opportunities to deliberate or discuss a change, faculty at multiple sites reported how they viewed institutional policies related to improved teaching as not relevant or punitive. Administrators could also consider what other context sensitive measures might promote informal conversations among colleagues related to active learning pedagogies.

All faculty interviewed had participated in geoscience faculty development. Those who described these socialization patterns also attributed some of their active learning strategies to these workshop experiences. One key informant described how enrollment imbalances between sections can arise when departments fail to ensure that those who teach shared large enrollment courses have comparable teaching skills. Under those circumstances, students may enroll more heavily in one section over another. It is worth noting that another key informant described how some geoscience departments elect to have lecturers teach large enrollment courses. The informant shared that lecturers do not always have access to faculty development. Moreover, institutions may limit access to faculty development due to employment policies (Kezar & Gehrke, 2013). These findings suggest that to ensure comparable high quality instruction of large enrollment courses, administrators should recognize the need for effective faculty development or other support structures. In addition, administrators should provide lecturers with greater access

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to faculty development so that all instructors have the skills needed to teach large enrollment courses.

How Department Decision Making Influences Program-Level Pedagogical and Curricular Concerns

Few studies examine the influence of departmental culture on teaching (Knight & Trowler 2000; Massy, Wilger, & Colbeck, 1994; Lee, 2007; Roy, Borin,& Kustra,2007). When the majority of faculty were engaged in the task of improving teaching practices, these studies revealed common departmental patterns of norms and behavior. The norms included frequent interactions with department colleagues, high tolerance and appreciation for differences, workload equity associated with teaching, peer observations, consensus process for decision making, balanced teaching and research incentives, and strong leadership (Knight & Trowler 2000; Massy, Wilger, & Colbeck; 1994). The sites where faculty reported regular informal conversations with departmental colleagues related to adoption of new teaching strategies exemplified many of the norms described by these studies. At these sites faculty described how the department tackled department-wide pedagogical or curricular problems. In fact, all sites that reported these departmental norms also reported that the majority of faculty in the department engaged in improvements in teaching practices. However, it is possible that a department with high levels of collegiality could be less engaged in improved teaching practices. An area of further research could investigate the relationship between the norms of department collegiality and improved teaching practices.

It is worth noting that two of the sites described more limited or combative departmental interactions and decision-making processes. These sites seldom tackled pedagogical or curricular concerns as a department. One key informant suggested that leadership, differential appointment types, or divides based on years of experience could explain norms that were less conducive to social interactions. The negative case findings suggest that further research is needed to examine factors that inhibit department collegiality.

How Institutions Evaluate Merit Policies Related to Instructional Measures

Researchers have argued that in order to achieve widespread adoption of active learning strategies, faculty reward structures need to value and recognize such teaching practices (Kezar, 2011; Fairweather, 2005, 2008; Massy, Wilger, & Colbeck, 1994). The faculty who were interviewed in the current study identified few means of incentivizing and recognizing improved teaching practices at their institutions. The case studies illuminate earlier findings related to the institutional challenge for measuring teaching in meaningful ways. Commentaries and studies have reached consensus that research is frequently favored in higher education reward structures (Fairweather, 2008; Coate, Barnett, & Williams, 2001). However, the perceptions of the faculty at these sites suggest a more complicated challenge.

Institutions that attempt to value teaching in merit metrics may actually limit innovative and active learning pedagogies. The findings suggest that even in departments where teaching is highly valued, faculty may limit their adoption of active learning depending on their perceptions about the degree to which active learning is valued with

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regard to merit evaluation decisions. While extensive studies exist related to student evaluations of teaching, few studies investigated the potential negative influence such instruments could have on risk taking in teaching (Spooren, Brockx, & Mortelmans, 2013; Moore and Kuol, 2005). Scholars engaged in reform efforts suggest the need to alter reward structures and to pursue national reform regarding these structures (O'Meara, Eatman & Petersen, 2015). National reform may need to precede institutional reform. At the very least, a primary recommendation is that college and university administrators interested in STEM teaching reform should be aware of the potential negative consequences of teaching metrics related to the adoption of active learning pedagogies.

Faculty Development

This study selected departments based on participation in two geoscience faculty development strategies: On the Cutting Edge Early Career workshops and Building Strong Geoscience Departments Traveling workshops. The study compared and contrasted the influence of these two strategies through the six cases. As described in Chapter 2, the two programs used different faculty development strategies. Both workshops were one-time workshops. Faculty development studies have identified one-time workshop strategies as less effective than faculty development strategies focused over an extended period of time (Henderson, Beach, & Finkelstein, 2011; Garet et al., 2001; Loucks-Horsley et al., 2003; Porter et al., 2003). One-time workshops are understood to be less effective because participants lack a network to support them as they make changes in practice following a workshop experience.

The Early Career workshop appeared to have the stronger lasting influence compared to the Traveling workshop experience. Early Career faculty recalled learning specific active learning pedagogies that they continued to use. They formed lasting professional contacts. In addition, faculty described how other departmental colleagues participated in Early Career workshops and brought more new teaching ideas into the department. At the two sites where a mix of Early Career and non-Early Career were interviewed, faculty described how multiple Early Career participants over time brought in new teaching ideas and propagated common values regarding high quality instruction. The Early Career workshop and other geoscience workshops were noted as providing infusions of teaching ideas that were shared across colleagues at these sites.

In contrast, for the Traveling workshop, faculty did not readily recall their experiences. As described in Chapter 3, the response rate was lower (16%) for identifying willing interview participants from two departments who participated in only the Traveling workshop. However, at two sites faculty did recall productive workshop experiences which laid the groundwork for positive changes. Institutional factors at both of these sites led them to apply to the program. Both of these sites also included Early Career participants. The two sites where faculty reported weaker effects from the Traveling workshops had less involvement in other geoscience faculty development initiatives. In addition, both of those sites reported departmental dynamics where the department was less connected as a group.

The current study advances knowledge of STEM faculty development related to curricular and teaching reform in several ways. First, the cases characterize how faculty

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discourse related to teaching can promote adoption of improved teaching practices. The case study approach allows the particularities of the context of each department to shed light on how these conversations play out and are perceived by faculty relative to their teaching practices. These findings suggest multiple ways that faculty development programs could play a role in fostering faculty conversations related to teaching. First, faculty development programs should provide opportunities during the programs to practice and learn the value of such conversations. Second, faculty development that uses a one-time workshop approach should address how participants will be supported in making changes following the workshop event. The cases demonstrate how a one-time workshop approach with sufficient intensity and relevance can foster lasting supportive networks. Third, the cases suggest that departments that are saturated with a large proportion of participants in faculty development initiatives are enabled in ways that permit barriers to strong teaching to be addressed with greater success.

The goal of many faculty development programs aims at changing faculty teaching practices. This study focused on perceptions of contextual influences related to the adoption of active learning pedagogies, rather than the process of measuring instructional practices. Existing studies suggest that faculty may not accurately report the amount of active learning pedagogy they employ (Ebert-May et al., 2011; Borrego et al., 2013; Henderson & Dancy, 2009). Future research designs could examine the relationship between enacted teaching practices and the socialization patterns identified in this study.

The Role of Evaluation in Faculty Development

The knowledge gained from this study demonstrates how context-sensitive evaluation can illuminate promising practices of faculty development. Faculty were asked to recall workshop experiences in their distant past. Early Career workshop faculty had participated in a workshop approximately two to twelve years before the time of the interview. Traveling workshop faculty had participated in a workshop about five to six years before the time of the interview. Because sufficient time had elapsed from the time of the workshop, the researcher was able to investigate how workshop experiences had persisted in influencing participants. This permitted a greater understanding of the role of lasting networks and how those networks supported faculty practices. These findings suggest that funding agencies may want to consider retrospective program evaluations rather than relying on funding strategies that limit evaluations to more immediate measures.

The study used a case study methodology that allowed deeper examination of how environmental context influences participants' decision making about teaching. Debra Rog (2012) identifies five areas of context that affect evaluation practice, including problem context, broader environment context, evaluation context, decision-making context, and intervention context (p. 28). Rog characterizes decision-making context as how a given evaluation can best serve decision makers in making decisions with confidence. In contrast, this study examined the decision-making context from the participant perspective within the environmental context. In addition, the study examined the decision-making context of the department.

The findings suggest that the decision-making context of the department may influence department-wide changes related to teaching. With the Traveling workshop approach, the intervention context and the department decision-making context overlap. The findings suggest that the success of the Traveling workshop intervention may in part be dependent on the existing departmental decision-making context. Moreover, the findings suggest how factors related to environmental context can influence the problem context. Understanding contextual relationships can better inform evaluation design and data collection. In this way, the study demonstrates how context-sensitive evaluation can illuminate ways in which one dimension of context relates to other contextual dimensions.

This study identified areas of data collection related to context that conveyed more meaning than standard demographics such as institution type. Evaluations could collect data in areas related to factors that faculty perceive as influencing their ability to adopt active learning pedagogies. Data collection areas include data surrounding the teaching practices and teaching loads related to general education/introductory courses, descriptions of the ways in which teaching is factored into departmental hiring decisions, and the role that student evaluations play in decisions related to faculty merit evaluations. The study suggests that each of these factors may reveal something about departmental values toward teaching. Evaluations could collect data related to these factors prior to faculty involvement in faculty development activities. Evaluative knowledge about these aspects could help characterize participants' context in ways that could inform program design.

Conclusions

From the six cases, the study concludes that two main factors related to departmental context influence the ability of faculty to adopt active learning practices. The results of this study suggest that having opportunities to deliberate and discuss teaching innovations, a network of colleagues undertaking the same changes, and a supportive reward structure would lead to wider adoption of practices. It suggests that the opportunity for faculty to engage in informal, regular conversations with departmental colleagues served to promote the adoption of new teaching approaches and ideas. The cases identified how courses taught among several department members became focal points for these teaching conversations. It illuminated ways in which decisions about hiring were emblematic of the value each department placed on improved teaching. In addition, these findings identified a relationship between the characteristics of department decision making and the department's ability to tackle program-wide pedagogical or curricular challenges. The traits that distinguished the interactions of these departments replicated many of the departmental norms identified by the few studies of the influence of department context on teaching practices.

In addition, the study illustrated how the ways in which faculty reward structures recognize teaching can impede the adoption of active learning pedagogies. The current study concluded that the ways in which teaching practice was measured, valued, and incentivized by institutions inhibited risk taking in teaching. The findings corroborated existing studies that identify the limitations of student evaluations as a primary measure for teaching. Moreover, it identified an institutional dissonance between the intent of

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valuing teaching and the measure put in place. When institutions measure teaching through student satisfaction, the findings identified how such measures provoke unintended consequences that limit teaching innovations.

The study revealed implications related to institutional policy, faculty development, and the role of evaluation. Context-sensitive evaluation uncovers how programs, policies, and practices related to STEM undergraduate education are situated in a shifting landscape. Evaluators share responsibility for understanding how and why the adoption of active learning pedagogies in undergraduate STEM education is not succeeding. With less effective teaching being the norm, the next generation of science learners may be limited in reaching their potential. Ever-increasing global challenges related to climate change, energy and resource disparities, food insecurity, and environmental degradation, raise the urgency of engaging learners and preparing students to meet these challenges. Tackling these challenges in the future is only possible when STEM instruction succeeds.

In conclusion, the cases in this study reveal faculty invested in teaching, but constrained by the limitations of their context. As one key informant observed "there was this sort of despair . . . like there's so little reward or . . . external valuation of this thing [teaching] that we internally value so highly." If STEM faculty development is to succeed in improving teaching practice, then institutional leaders and funding agencies need a greater understanding of how faculty context shapes practice. Evaluation stands ready to play its part. Evaluators have an obligation to contribute to more enlightened change.

With context as a guide post, evaluation illuminates new paths for decision makers to tackle barriers and make excellence in STEM teaching possible.

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Appendices

Appendix A: Invitations to Participate

Invitation to Participate in Research
Subject: Request from On The Cutting Edge | Building Strong Geoscience Departments

Dear Name,

I am writing to ask for your participation in a phone interview which will help me complete my dissertation studies. The study includes a limited, highly select set of faculty who meet the criteria for this study, which includes you.

I was particularly interested in hearing your insights about teaching because of your disciplinary background in _____ as well as your past participation in _____ workshop in ___. The study investigates how departmental and institutional context may influence faculty teaching approaches.

I am hoping that you would be willing to participate in a 30-45 minute phone interview to learn more about your teaching strategies and insights.

I am available to conduct interviews between 9:00am and 5:00pm (CST) Monday, Tuesday, Thursday, or Fridays. I can also schedule a limited number of interviews before 9am OR after 5:00pm (CST). Please let me know some possible dates/times that works well for you.

If you are willing to participate, please know that your name will not be used in any reports. I will assign identifiers to each interview and piece of data so that no personally identifiable information is available. Responses will be anonymous to the extent that your comments do not provide identifiable information.
I would appreciate your response by _____. Thank you for your consideration.

Ellen Iverson

Invitation for Key Informant to Participate in Research
Subject: Request from On The Cutting Edge | Building Strong Geoscience Departments

Dear Name,

I am conducting a study to investigate how departmental context may influence faculty teaching approaches. This study is to fulfill the requirements for my dissertation studies.

I contacted you because of your past involved in the On the Cutting Edge Early Career workshop and as a recognized leader in the field of geoscience education.

As part of my dissertation work, I am interested in discussing my preliminary aggregate findings with key informants, like yourself. I am writing to see if you would be willing to participate in a telephone interview (30 to 40 minutes). I am hoping to conduct these interviews during the week of _____.

If you are willing, I would share a short summary document with you prior to the call. Then, I would gather your insights and interpretations.

The aggregate findings are from an interview study which included former participants from On the Cutting Edge Geoscience Early Career workshop and from the Traveling workshops for the Building Strong Geoscience Departments program.

I am available to conduct interviews between 9:00am and 5:00pm (CST) Monday to Friday. I can also schedule a limited number of interviews before 9am OR after 5:00pm (CST). Please let me know if there are times the week of _____ that might work for you.

Thanks so much for your consideration.

Ellen Iverson

Appendix B: Protocols

Case Study Interview Protocol
Introduction
Hello, this is Ellen Iverson. *Does this time still work for you for the interview?*
As I shared in my email and on the consent form that you signed, I am conducting a study to investigate the influences of departmental context on faculty members' ability to adopt active teaching strategies. This study is to fulfill the requirements for my dissertation studies.
I contacted you because records show that you previously participated in the *NAME OF WORKSHOP AND DATE OF IT*
The interview will take no more than an hour. Will that work?
Great, I am going to ask you a series of questions about your teaching experiences at *NAME OF INSTITUTION.* One aim of the study is to understand what factors support the use of active learning teaching strategies by faculty. I was particularly interested in geoscience because of the varied disciplines that can make up different departments.
I'd like you to answer as honestly and as candidly as possible. As you know from the consent form, your name will not be used in any report. I would like to audio record our conversation and transcribe it later. Is that okay with you? Any other questions before we get started?

Timing	Protocol questions:
7 minutes	1. First, I would like to start by talking about your teaching. I would like you to think of a time in teaching when you felt most energized, alive, most fulfilled. What made that teaching experience memorable?
	[wait time]
	Please describe that teaching moment.
	How does that moment align with your philosophy of teaching?
	Prompts as needed: What were you doing in the classroom? How were students responding or engaged? What inspired you to try this approach? Is there anything about the classroom context that is important for this approach to be effective? How did the NAMEOFPROGRAM influence you in any way with this approach?
	[Depending on whether the moment is aligned with active learning pedagogies]
	Would this style of teaching be your preferred approach? What prevents you from using this approach more frequently?
5 minutes	2. a) Now switching gears a little, how do your network of

colleagues support or influence your teaching? (Note: They may have alluded to colleagues in previous question)

[wait time]

Prompts as needed: How do colleagues influence your decisions about teaching? Tell me about those kind of conversations. Who are those colleagues (are they members of your department, disciplinary community, or institution)?

b) Your research is in _____(climate science, limnology, oceanography, geology, environmental science). How have your disciplinary colleagues influenced your teaching practices?

5 minutes   3. Now I'd like focus more on your department. So, how is teaching valued or recognized?

[wait time]

Prompts as needed: How does your department view innovating and trying new teaching approaches? How do new faculty members come to understand your department's philosophy toward teaching? How is teaching factored into promotion and tenure? What barriers to teaching related to your department or institution have you experienced?

3 minutes   4. Now, this may not apply to your situations but if there are differences in how different faculty member think about teaching in your department, how are they expressed and addressed?

[wait time]

Prompts as needed: How do disciplinary differences influence different department colleagues' approaches and philosophies about teaching?

10 minutes   In your opinion, how would you describe the professional sense of community in your department? [wait time]

Prompts as needed: How would you describe the faculty in your department right now as a group? How do disciplinary differences within the department influence the sense of community? Who are the opinion leaders among your faculty and why? Do faculty members participate in major decisions

	about curricular programs as well as the day-to-day decisions?
3 minutes	[If not already addressed in how they have responded to previous questions about influences and colleagues] To what extent, and in what ways, is teaching valued at your institution? In what ways has your institution influenced your teaching? [wait time]
	Prompts as needed: How have you been supported? What barriers do you perceive?
5 minutes	[Depending on how they responded to Question 2] Now coming back to your teaching. When you want to try something new in your teaching, what inspires you? How do you learn about new teaching strategies? Tell me more about your learning process. [wait time]
5 minutes	I'd like to return to your involvement in [the Early Career workshop or Department workshop. [wait time]

[Depending on what was shared earlier in interview]
Can you tell me more about your experience? In what ways has [the Early Career workshop or Department workshop] influenced you [or your department] ?

Prompts: Would you be where you are now without that involvement? How is life different as a result of your participation?

Key Informant Interview Protocol

Introduction

Hello, this is Ellen Iverson. *Does this time still work for you for the interview?*

As I shared in my email and on the consent form that you signed, I am conducting a study to investigate the influences of disciplinary culture, institutional culture, and departmental culture on faculty members' teaching beliefs, teaching styles, and their teaching practices. This study is to fulfill the requirements for my dissertation studies.

I contacted you because [you are the Principal Investigator for xxx] OR [you are a recognized leader in the field of geoscience education].   *The interview will take no more than 45 minutes. Will that still work?*

Great, as I shared in the email, I am interested in your observations about the preliminary findings from the study. You are particularly knowledge about [the program] or [the geoscience education community] . For that reason your insights and interpretations are of interest.

Did you have a chance to review the preliminary findings report? If not, I am happy to take a few minutes to review it.

I'd like you to answer as honestly and as candidly as possible. As you know from the consent form, your name will not be used in any report. No identifiable information will be shared. I would like to audio record our conversation and transcribe it later. Is that okay with you? Any other questions before we get started?

Timing	Key Informant Interview Questions
5 minutes	Reviewing the case findings about departmental socialization and improved teaching, what surprised you the most? **Prompt:** How is it different than what you expected?
	So is that drawing from your own personal experience in your department or from your experience in the community?
10 minutes	I want to shift gears and ask what aspects immediately struck you with the findings as presented? **Prompt:** How is it different than what you expected? [For Program Leaders]How do the findings reflect the philosophical guiding principles of the faculty development program?
5 minutes	What are your impressions of the findings related to the two faculty development programs? Prompts:
10 minutes	In thinking about what you learned about being a leader in [ ] , if you were involved with a group in designing a new faculty development program in geoscience, what considerations do you think are important for fostering changes?
5 minutes	Any other observations that you have that I have not asked about?

Thank you so much for your willingness to participate.

Appendix C: List of Document Artifacts

Department and Institution Listing of Documents

Department	Documents
Marble	Department newsletters (2014, 2015); Strategic plan; History and Degrees Awarded; Institutional Quick Facts; Institutional Vision, Mission, and Values; Institutional Strategic Positioning, Admissions Video
Copper	Department newsletters (2014, 2015); Geology Student Handbook; Facilities Description; Program description; Institutional History, Mission, and Values; Institutional Degrees; About the Institution
Jasper	Department mission statement; Department programs description; Outreach program description; Career profile description; Grants awarded descriptions; Two presentations from the American Geophysical Union; Institutional History; Institutional Mission and Vision; Institutional Quick Facts
Gabbro	Department Position Statement; Department Outcomes Assessment Matrix; Department Mission Statement; Department Facilities Description; Department Newsletter (2010); Career Profile; Institutional Teaching and Learning Resources; Institutional Mission and Strategic Plan; Institutional Quick Facts; NSF Award Search
Olivine	Department Overview and Mission Statement; Department Newsletter (2012); Facilities Overview; Description of Center; Description of Lab; Letter from Chair; Career Profile; Institutional Mission and Objectives; College Mission, Vision & Goals; Teaching and Learning Center Description; Institutional Quick Facts; Institution History
Granite	Department Overview and Mission Statement; Undergraduate Description of Courses and Syllabi; Facilities Description; Institute Description; Institutional Campus Map; Institutional Mission Statement; Institutional Quick Facts