The Relationship Between Instructors' Conceptions of Geoscience Learning and Classroom Practice at a Research University

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ABSTRACT

Reform of undergraduate science education will need to be supported with effective professional development for current and future faculty. The professional development programs will need to address the knowledge, skills and beliefs of higher education faculty so that they can implement the kind of effective practices that results in the intended learning and meets the needs of diverse learners. To support the design of these programs, this research characterized the relationships between faculty's conceptions of teaching and learning on their teaching practices. Teaching faculty at a Doctoral/Research University were randomly interviewed to assess conceptions with respect to: 1) individual faculty learning, 2) student learning based on academic level, 3) how teaching is valued by the organization and 4) course goals. Additionally, classroom observations were conducted to determine the level of student-teacher interaction and cognitive engagement of the instructor and students with graphical and symbolic representations, as well as other manipulatives. Observations indicated teacher-centered classes across all academic levels. These data contrasted the subject's conceptions that cognitive and technical skill development is best achieved through self-directed learning. Analysis of the interviews and observations suggested the contradiction between learning practices the subject viewed as effective and the utilized teaching methods resulted from two major barriers: 1) the instructors' conceptions on the evolution of student learning and 2) an institutional reward structure that doesn't support the development of effective teaching practices.

INTRODUCTION

It is generally assumed that post-secondary science classes are conducted using the lecture format, even though these methods are known to promote memorization in students, and not true understanding of the material. The focus of this study is two-fold: to quantify the prevalence of lecture based courses in a Doctoral/Research University through classroom observations and to understand how the instructors' conceptions of learning influence the teaching practices observed in the classroom. Reform of undergraduate science education is constrained by a number of systemic issues including faculty teaching expertise and the overly specialized research training of PhD and post-doctoral students. This can leave both current and future faculty poorly prepared to teach effectively (Gappa et al., 2007; Golde and Dore, 2001). Improving instructor knowledge and skills to teach effectively can be supported, in part, through effective professional development programs. The goals of professional development programs should be based upon the knowledge and skills required for effective teaching, as well as an understanding of the typical values, beliefs and misconceptions about teaching and learning held by graduate students, post-docs, and faculty.

Effective teaching is the practice that results in the intended learning, and meets the needs of diverse learners most of the time. Effective teaching requires a diverse set of knowledge including a research-based understanding of learning; the nature of diverse student knowledge; the design of learning environments that align learning objectives, assessments, and instructional activities; and how to progressively refine courses based on reflection and feedback. Likewise, effective teaching also requires instructors have the skills to use this knowledge to design and implement effective learning environments. The values and beliefs of instructors can also impact their practice. Self-efficacy refers to an instructors' belief in their capability to impact student learning and perform the tasks associated with their academic position (Kagan, 1992a,b). Research on K-12 teacher education has shown that greater self-efficacy has been associated with changes in teaching practices (Smylie, 1989), use of new curricula (Poole et al., 1989) and increased student achievement in reading and math (Ashton and Webb, 1986).

The actual teaching practices employed by instructors have a major influence on how students learn (Trigwell and Shale, 2004). Unfortunately, there is often a misalignment between instructor conceptualization of the learning outcomes derived from their teaching and the actual teaching practice in the classroom. Previous surveys showed that higher education faculty generally believe their teaching is student-centered and effective in facilitating student learning, though classroom observations indicate that the dominant teaching practice in use is a teacher-centered, didactic lecture format focused on information transfer (Murray and Macdonald, 1997; Norton et al., 2005). Lecture-centered teaching practices that often dominate post-secondary science courses tend to promote rote memorization and poor student motivation (Trigwell et al., 1999; Trigwell et al., 1998). Teaching for conceptual understanding, on the other hand, is best achieved through student-centered teaching practices that engage students in authentic scientific inquiry rather than teacher-centered approaches that include traditional lecture-centered teaching practices (Kember, 1997; Samuelowicz and Bain, 2001). To

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effectively support change in geoscience education, the barriers that create this discrepancy between instructor conceptions and teaching practices must be identified in order to determine appropriate interventions (Bolhuis and Voeten, 2004).

The focus of this study was to assess the level of the faculty member's self-efficacy and the relationships between faculty conceptions of the nature of geoscience learning and their own practice in the classroom. Our exploratory investigation collected faculty interviews and classroom observations. Interviews were conducted to determine faculty conceptions of teaching and learning and classroom observations were conducted to identify teaching practices. The goals of our research are to: 1) identify faculty conceptions of methods used to learn by both themselves and students 2) identify factors that influenced the faculty self-efficacy and 3) compare the faculty's conceptions of effective learning strategies with teaching practices utilized in the classroom. These interviews should help identify the factors that impact instructor self-efficacy in a university geoscience department and the major systemic barriers impacting instructor self-efficacy, and help shape. Ultimately, the results presented here may provide a useful foundation that helps define important goals and objectives of professional development programs to support undergraduate geoscience education reform at similar doctoral/research institutions.

MATERIALS AND METHODS

Faculty Interviews

Kagan (1992a) defined teaching beliefs as "pre- or in-service teachers' implicit assumptions about the students, learning, classrooms and the subject matter to be taught." Broadly defined, teaching beliefs describes the underlying assumptions regarding both the practice of teaching as well as the practice of learning. For the purposes of this study, learning must be differentiated from teaching. Teaching beliefs can therefore be broken into two categories: teaching conceptions and learning conceptions. Teaching conceptions describes the ideas and practices that the individual sees as the most effective methods of teaching. For this study, teaching conceptions will be defined as any pre-determined belief with regards to the internal and external variables that influence the teaching practices in the classroom. Learning conceptions describes the instructors' beliefs with regards to how students learn. Teaching conceptions describes the instructors' beliefs.

The authors developed a directed interview to qualitatively identify major characteristics of faculty conceptions about learning in a Geoscience department at a Doctoral/Research University. The authors conducted a thematic analysis to systematically assess the interview results (Aronson, 1994). Ultimately, four conceptual themes based on concepts discussed by other researchers (Bolhuis and Voeten, 2004; Slavings et al., 1997) were explored by the interview: 1) individual faculty learning, 2) student learning differentiated between the academic levels of non-major undergraduate, major undergraduate and graduate student, 3) the value of teaching as held by the interviewee and 4) course goals based on academic level.

The first conceptual theme, individual faculty learning, explored the techniques faculty utilized when learning new material themselves. The second conceptual theme asked the faculty to describe the methods they believed students utilized when learning new material. By asking if the methods utilized were different based upon academic level, we were able to see if the faculty differentiated learning techniques as student expertise theoretically increased. The third conceptual theme explored the faculty's perceived value of teaching from both internal (personal value) and external (colleagues, administration) viewpoints and how this value impacted their individual teaching practices. The final theme explored the course goals the faculty deemed to be most important and was again differentiated by academic level.

The directed interview utilized to explore these themes consisted of four major questions (Table 1). One instructor/teacher educator and four science education researchers discussed and debated the interview vocabulary to improve clarity of questions and improve overall interview validity. Interview questions were asked in the sequence listed to avoid biasing answers regarding student learning. Interview subjects received no guidance beyond the follow up questions listed in italics. Faculty members actively teaching in a geoscience department were divided among rank (support staff, assistant professor, associate professor and full professor) and selected using a random number generator. Teaching

TABLE 1. INTERVIEW QUESTIONS LISTED IN ORDER ASKED

TOPIC	QUESTION
Subject Learning	You need learn a new skill. You have only three months to become proficient. Explain how you would accomplish this? Explain your reasoning for the steps you would take. *It may be easier to recall something you had to learn in your past (if necessary)*
Student Learning	How do you think students' learning differs between academic level (major/non-major, undergraduate/graduate)? *How do you support that method of learning in your classroom? Can you give specific examples?* *How do you know students are learning in your class? What evidence do you have to support student learning?*
Teaching Value	How do you feel teaching is valued in this department/college? *How does that impact your teaching style?*
Course Objectives	What are your goals for your students? In other words, if your students take only one thing away from your class, what would it be? *Does that change based on the student's academic level? If so, what goals change?*

TABLE 2. CODES, DESCRIPTIONS AND EXAMPLES OF INSTRUCTIONAL SCAFFOLDING STRATEGIES FROM (STUESSY, 2006)

RECEIVING/ DIRECTION	PERFORMANCE /INITIATIVE	DESCRIPTION	EXAMPLES
5	1	Individual students are directed to listen as the teacher or another student talks to entire group; students are directed to read or do seat work.	Direct instruction models; lecture, silent reading, independent practice, seat work.
4	2	Individual students respond orally or in writing to questions asked by the teacher, in whole group.	Teacher-led recitation; question and answer; discussion led and directed by the teacher.
3	3	Students in pairs or small groups work together under the teacher's supervision - with discussion; all groups do basically the same task.	Student discussion in groups; task completion; verification laboratories, cooperative learning models.
2	4	Groups and/or individual students work on different tasks with some choice options; loosely supervised by teacher.	Student– or group-initiated work on choices of options provided by the teacher; "centers" or learning stations.
1	5	Student pairs or small groups discuss, design, and/or formulate their own plans for working in class on a specified task; minimal supervision.	Open-ended laboratory or project work.

faculty members, hereby referred to as subjects, were interviewed in order until approximately 50% at each rank had been interviewed. A total of 12 interviews were conducted and transcribed by two authors and combined into a summary account to ensure the entire interview was recorded. Interviews were conducted on two support staff (24 ± 13 years), two assistant professors (9 ± 7 years), two associate professors (18 ± 8 years) and six full professors (31 ± 10 years). A single author analyzed the interviews to avoid potential reliability conflicts. Interviews were quantified using thematic analysis (Aronson, 1994), a keyword/concept index derived from analysis of the interviews. Each concept was quantified by summation of mentioned keywords or phrases by the subjects throughout the interview. For example, if the subject mentioned that undergraduate, non-major students learn through memorization and memorization was a keyword or concept, memorization would get one check. In order to ensure the confidentiality of the participants, the sum of each concept was converted into percent of subjects mentioning the concept.

Classroom Observations

Classroom observations of interview subjects were conducted and graphically visualized using the Mathematics Science Classroom Observation Profile System (M-SCOPS) developed by Stuessy (2006). The MSCOPS was created to characterize the practice of pre-service K12 teachers in mathematics and science methods classes in order to assist them in understanding how hands-on experiences, instructional materials, and student -centered instructional strategies can be used to facilitate conceptual understanding of their students (Parrott and Stuessy, 2000; Stuessy, 2001a,b). The observation tool has been extended to characterize the temporal nature of instructor practice and student engagement with discussions, representations, and manipulatives. Reliability between three observers was achieved through training sessions involving video observations of science classes, M-SCOPS scripting of these observations, visualization of M-SCOPS profiles and subsequent discussion of results.

M-SCOPS profiles visualize the level of teaching and learning engagement as well as the representations, manipulatives and technology used in class. Teaching and learning engagement is quantified by summing Receiving/Direction (R/D is student receiving) with Performance/Initiative (P/I is student acting) where the sum is six and is reported R/D-P/I. The levels of these interactions are 5-1 (lecture), 4-2, (teacher-guided recitation), 3-3 (student group discussions), 2-4 (student/ group presentations), 1-5 (open-ended laboratory work) and 0-6 (independent projects) (Table 2). Table 3 describes the different levels of instructor and student engagement. Level one cognitive engagement is defined as ***Attend*** and includes relatively passive activities such as observing and reading. Level two cognitive engagement is defined as ***Replicate*** and includes explanations, clarifications and examples. The third level of cognitive engagement is defined as ***Rearrange***; this level includes connections, comparisons of material and descriptions of parts of a system. The fourth level of cognitive engagement is defined as ***Transform***; this level includes multiple representations of a system and putting complex parts together to form a system. Level five cognitive engagement is defined as ***Connect*** and includes analyses and hypotheses. Finally, level six cognitive engagement is defined as ***Generate*** and includes justification and defense of material. Generalized teaching methodologies can be easily identified by viewing M-SCOPS profiles, where teaching-centered actions plot left and student-centered actions plot right.

RESULTS AND DISCUSSION

Faculty Teaching Practices

Classroom observation data collected during this experiment was visualized and interpreted via M-SCOPS profiles and showed that all courses were generally

TABLE 3. CODES FOR ACTIONS OF STUDENTS WITH MULTIPLE REPRESENTATIONS IN RECEIVING AND PERFORMING FROM STUSSEY (2006)

ACTION CATEGORY	LEVEL (CODE)	INPUT	ACTION
Attend	**1**	External or superficial features, attributes, challenges to perform a level 1 action.	Listen to, attend to, observe, watch, read, view.
Replicate	**2**	Examples, identifications, descriptions, explanations, clarifications, calculations, documentations, duplications, measurements, reproductions, demonstrations, algorithms, challenges to perform a level 2 action.	Recall, remember, list, tell, identify, label, collect, examine, manipulate, name, tabulate, identify, give examples, describe, explain, clarify, calculate, document.
Rearrange	**3**	Comparisons, groupings, sequences, patterns, rearrangements, balancing, classifications, disassembled parts of a whole; processes of putting parts of a whole together, challenges to perform a level 3 action.	Compare, group, put in order, rearrange, identify a pattern, paraphrase, balance, classify, identify parts of a whole, assemble parts to make a whole, disassemble parts of a whole.
Transform	**4**	Alternative points of view, distinguishing one from another, differentiations, arrangements of complex parts into a whole system, transformations, changes, challenges to perform a level 4 action.	Represent symbolically or pictorially, experiment, interpret, contrast, apply, modify, make choices, distinguish, differentiate, transform, change, arrange complex parts into a system.
Connect	**5**	Connections, relationships, justifications, inferences, predictions, plans, hypotheses, analogies, systems, models, solutions to complex problems, challenges to perform a level 5 action.	Connect, associate, extend, illustrate, explain relationship in a system, infer, predict, plan, generate hypotheses, use analogies, justify, analyze, generate solutions to complex problems already conceived, rank with justification.
Generate	**6**	Analyses, evaluations, summaries, conclusions, abstract models and representations, problem scenarios, challenges to perform a level 6 action.	Express conceptual models, define relationships in new systems, generalize, recommend, evaluate, assess, conclude, design, generate a problem, solve a problem of one's own generation.

teacher-centered. The M-SCOPS show the cognitive M-SCOPS plots skewed to the left are teacher-centered and plots skewed to the right are student-centered; the magnitude shows the cognitive engagement of the material as previously discussed. Both the instructor and the student participation in the honors classes were at much higher levels as well as the uses of symbols and graphical representation when compared to the other classes observed. The M-SCOPS also indicated that for the non-honors classes only two of the ten classes observed showed any significant student engagement. The observations also indicated that about half of the classes had instructors that used significant graphical or symbolic representations during instruction. M-SCOPS plots showed that instruction was highly variable for the graduate classroom observations, though they were fairly minimal in terms of student engagement as well (Figure 1). Teaching-practices were dominated by lecture (Instruction), slideshows with notes (Symbols) and to a lesser extent diagrams (Pictures). These symbols and pictures were often of lower levels of cognitive engagement, ranging from ***Attend*** to ***Rearrange***. For example, the slides may have showed a figure of the rock cycle or a comparison of different rock types. M-SCOPS showed minimal interaction in the non-honors and some of the graduate classrooms; student engagement in these classrooms generally consisted of single students answering questions posed by the instructor.

Knowing that many faculty members utilized the teaching-centered approach, it was important to consider the level of cognitive engagement of the students. Higher levels of cognitive engagement challenges students to build connections with prior knowledge that can promote both content learning and cognitive development. Average cognitive engagement observed in this study (symbol representations received) were highest in the graduate classes (3.46) and approximately the same at the undergraduate level (2.88, 2.91) indicating slightly more connections being made with the content in the graduate courses (Table 4). However, the level of cognitive engagement being acted upon by the students was generally in the 1.0-1.6 range, indicating students were not actively involved in the learning process and further confirmed the dominance of teacher-centered practices in classrooms of all academic levels. There were instances of increased interaction beyond the basic lecture style of class. For example, some subjects lead the students in directed discussions related to course content, as well as used multiple representations such as diagrams, pictures, simulations and physical models. This appeared to be most common in smaller, undergraduate classes; more specifically the non-major honors classes.

Faculty Conceptions of Teaching and Learning

In general, faculty learning utilized active, self-directed methods of knowledge construction and illustrates a high level of expertise which contrasted conceptions of student learning, characterized by more passive forms of learning such as memorization (Figure 2A and 2B). Results show approximately 90% of the subjects described learning a new technical skill required a two-part process: reading and practicing (Figure 2A). Most subjects would first conduct a literature review of the new skill to assess the current state of knowledge. As one subject stated, "there is no reason to re-invent the wheel." Upon determining the state of knowledge, the subjects generally described finding a mentor to gain advice and/or begin to practice the new skill. This method is analogous to learning at the graduate level, and characterizes authentic scientific inquiry. Likely, the faculty has fully developed the cognitive skills necessary for their profession, and therefore may not consider the development and/or utilization of cognitive skills in teaching practice development. Also, the subjects' method of learning consists of reading and action, and isn't/can't often be supported in traditional classroom education. This was evident when looking at the classroom observations, where most of the data indicated that lecture was the dominant educational methodology used by subjects regardless of academic level. Table 4 summarizes the M-SCOPS results and shows that there was little difference in teaching practice utilized, regardless of the academic level of the class. The majority of students in the observed classrooms were undergraduates who were likely inexperienced in self-directed learning. The major objectives of science education reform have evolved to a focus on the development of practices and settings that develop learner's "habit of mind" (Duschl and Gitomer, 1997) to reason scientifically and engage in scientific inquiry (American Association for the Advancement of Science Project 2061, 1989). This goal assumes students can learn the cognitive and manipulative methods of science exploration that generate data and evidence. It also assumes that students can use the reasoning and argumentation skills needed for theory development and evaluation that link evidence to explanations.

Perhaps one of the most interesting results of the interviews showed only 8% of the teaching faculty specifically described teaching practice as a major factor-influencing student learning (Figure 2B). This may suggest that the subjects believed that teaching practices employed in the classroom have little to no impact on student learning outcomes, and as such places the burden to learn directly on the student. The subjects' had previously indicated a personal preference for self-directed learning, which may explain the rational for placing the responsibility to learn solely on the student. As stated above, it is likely that many undergraduate students have not been exposed to this type of self-directed learning, which would call into question the potential effectiveness of these teaching practices.

Faculty conceptions of student learning based on academic level illustrated the fundamental difference in cognitive expertise between the faculty and students, where student learning progressed from simple cognitive skills (memorization) in undergraduate students to higher-order cognitive skills in graduate students (problem-solving) (Figure 2C). However, approximately 15% of the subjects responded that there was no difference in how students learn, though they agreed that subject terminology was more complex at the higher academic levels. It appeared that these subjects believed that students had the cognitive abilities to handle the material, though lack of specific terminology may limit the students' ability to technically describe geological processes. This was an understandable conception in that several terms in geology can be used to describe the same general process. For example, an impermeable rock unit is called a confining bed or aquitard when related to groundwater, yet the unit is called a seal when it is related to petroleum geology. Overall, the subjects appeared to answer the question as if it were hypothetical, rather than the ways students actually learn. In other words, the subjects answered the question as if it were "how can students' learning differ between academic level" rather than, "how does students' learning differ between academic level." Interestingly, one of the subjects that believed students learn differently based on academic level stated that students just starting higher education are often in "memorization-mode" which leads to students focusing on learning facts. The subject continued stating that as student's progress through the major, they begin to realize the importance of these facts and how they can be utilized in more complex ways. The student development described by this subject highlights the importance of student motivation and content relevance in learning. Approximately 69% of subjects stated motivation has a major impact on student learning (Figure 2B). Often, non-major students are taking the course to fulfill a requirement and thus may have the attitude that the material is irrelevant with respect to personal higher education goals. Conversely, graduate students realize the importance of the material being presented in class, and are therefore highly motivated to learn and apply the material to their own research.

Clear course objectives (goals) may lead to more directed-teaching practices, though accurate assessment of student learning enables instructors the ability to identify effective teaching practices. Generalized faculty teaching goals included the development of problem-solving skills, student interest and student knowledge-base (Figure 3). Goals for non-major undergraduate students focused on conceptual model development while goals for upper-level and graduate students focused on problem-solving skill development. These goals are generally in agreement with the faculty conceptions of student learning based on academic level, where undergraduate non-majors are in "memorization mode" and more experienced graduate students are looking to apply their knowledge.

One of the more difficult aspects of teaching is finding ways to effectively evaluate student learning, here defined as true conceptual understanding. The most common methods of learning assessment mentioned by the subjects was grading students' exams and quizzes, as well as the evaluating the quality of the questions students asked in class (Figure 2C). While exam and quiz grades indicate material has been learned, it does not indicate complex student understanding. In a multi-institutional survey of chemistry faculty perceptions, Slavings and others (1997) showed that open-ended assessments including essays

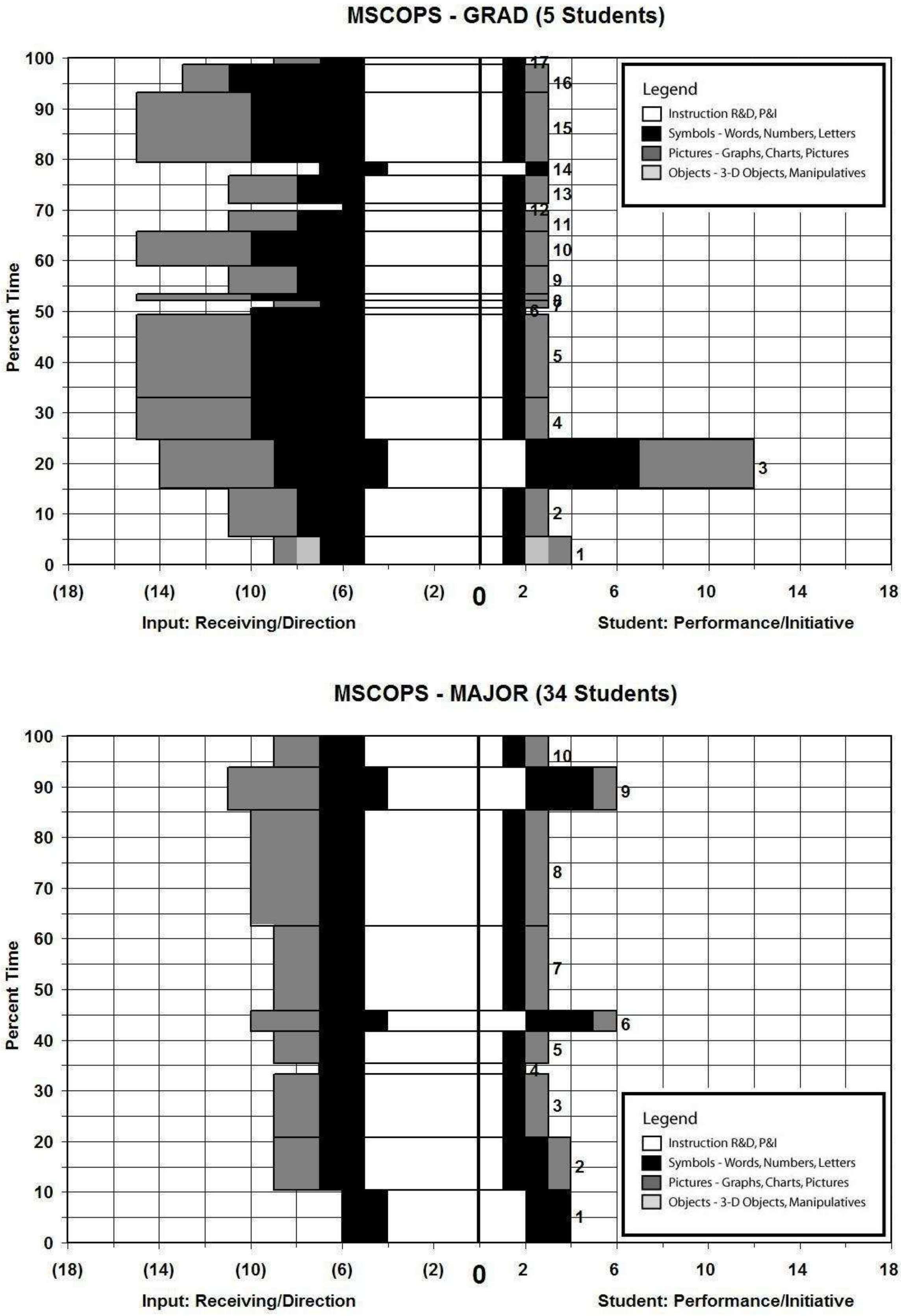
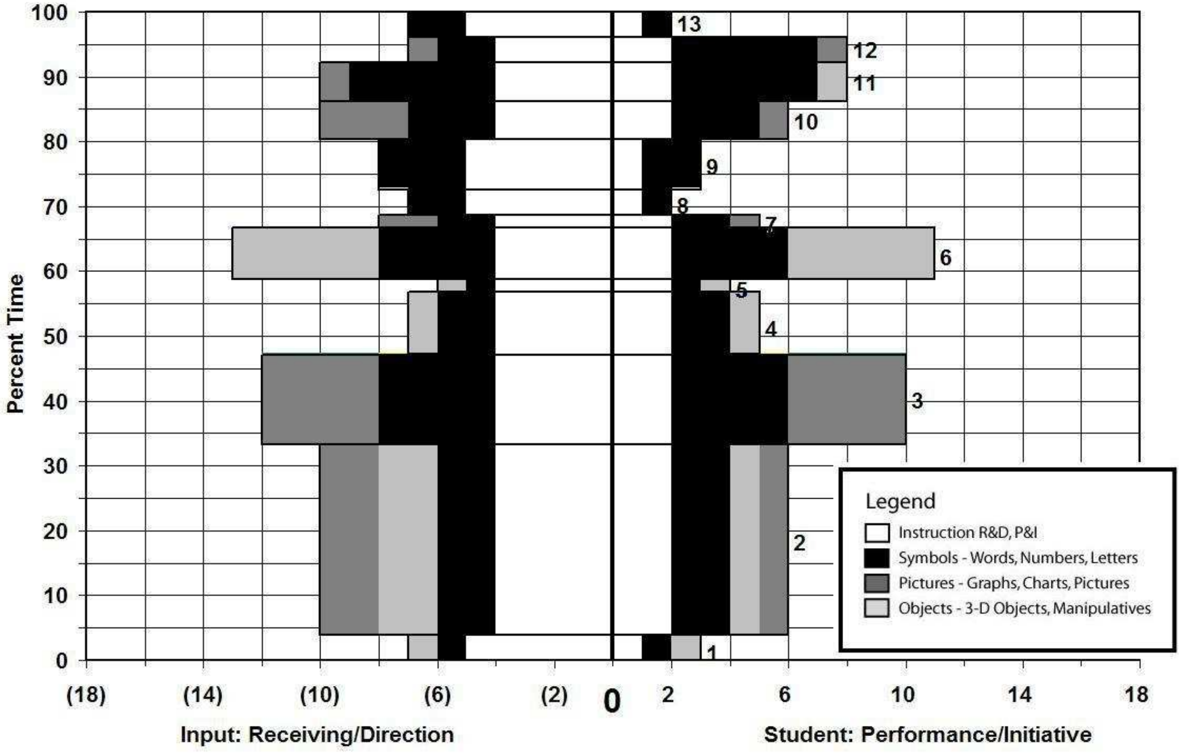
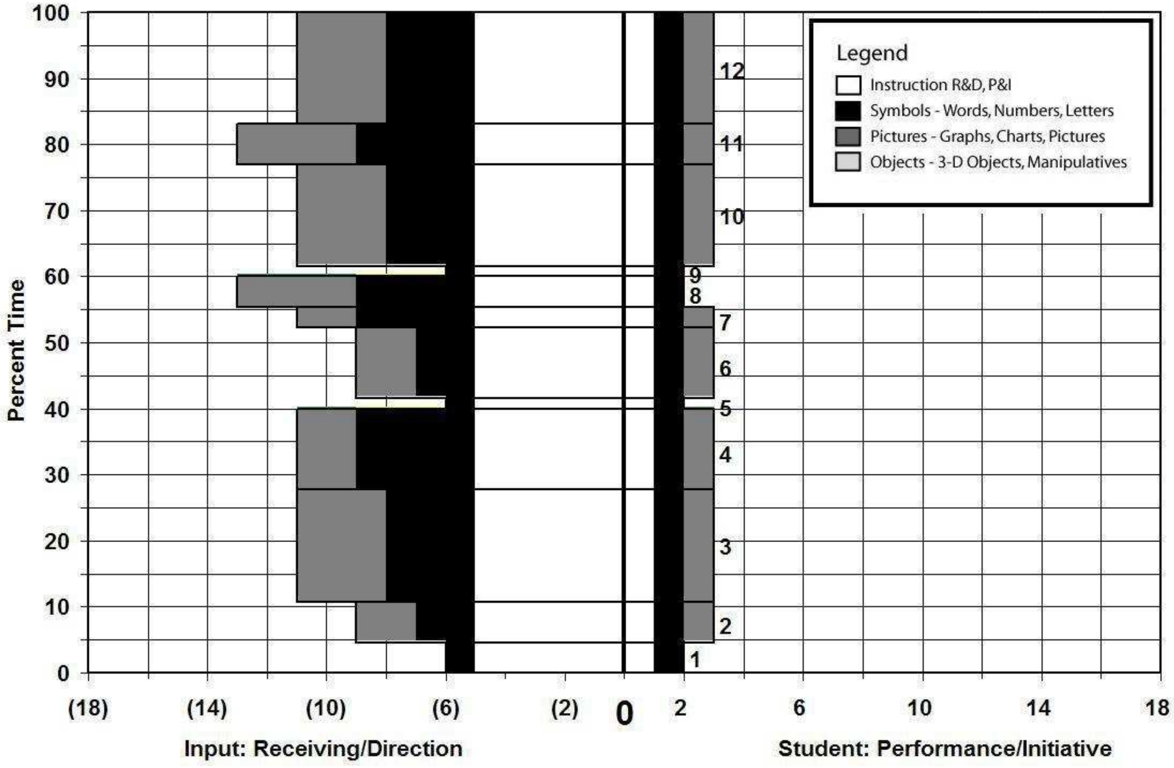


FIGURE 1. M-SCOPS class observation profiles. The four observations include a representative undergraduate non-major class, undergraduate non-major honors class, undergraduate major class and a graduate class. Teaching-centered classes plot left and learning-centered classes plot right. The numbers on the right indicate the coding sequence.

MSCOPS - NON-MAJOR HONORS (15 Students)



MSCOPS - NON MAJOR (100 Students)



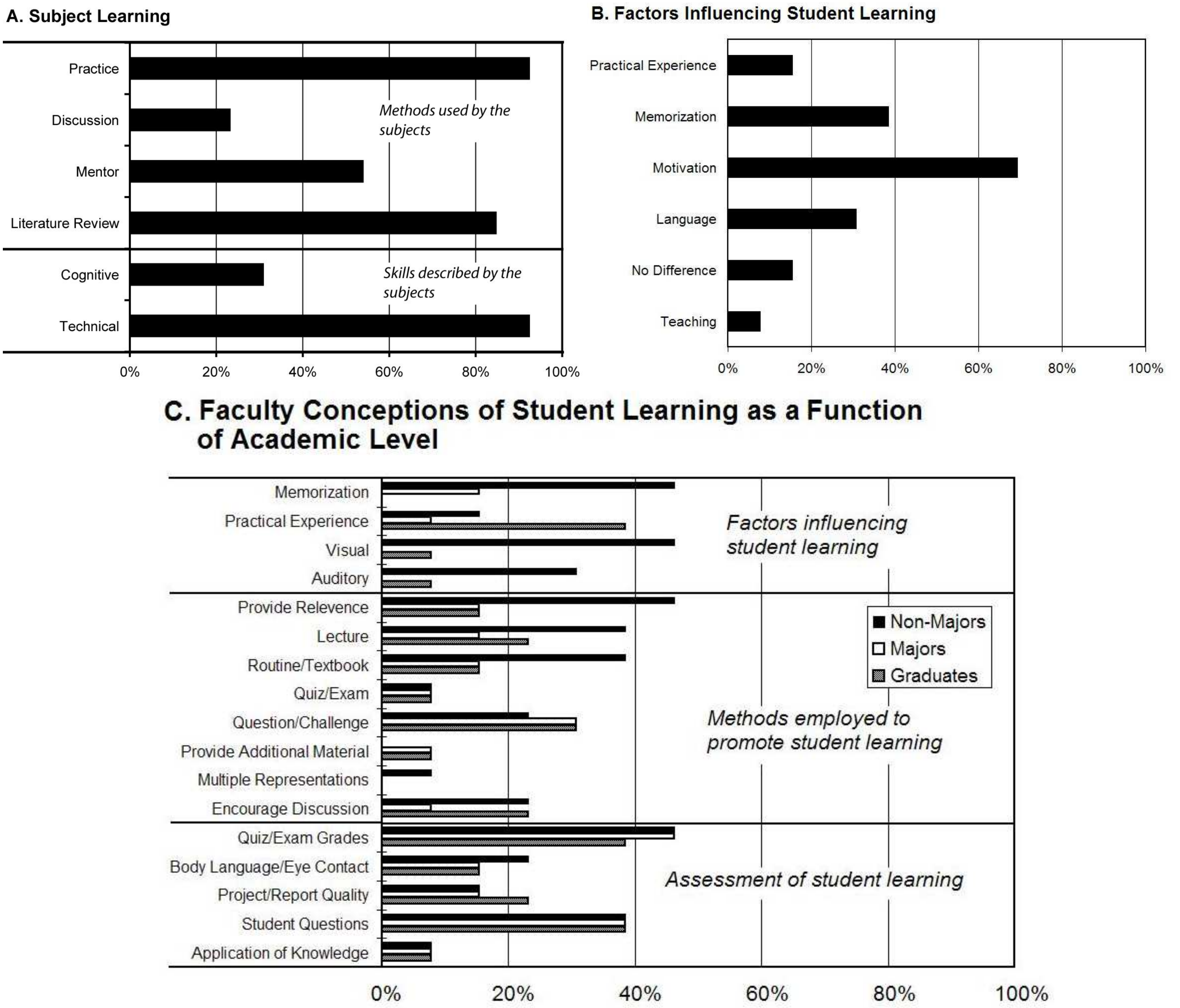


FIGURE 2. Interview analysis of faculty conceptions of learning. Values reported are the percentage of subjects who spoke to the specific topic. Conceptual themes reported include (A) faculty learning, (B) factors influencing student learning, (C) and differences in student learning as a function of academic level.

and reports tended to be the most accurate method of assessing student learning. Prosser and others (1994) showed that examinations are not the best method for evaluation because some "students exhibit substantial conceptual misunderstandings even after passing university examinations on the topic." However, when students ask topical questions that relate material being presented in the class to prior knowledge, cognitive processes linking new material with pre-existing conceptual models are displayed. As stated above, the development of conceptual models is the most effective way to promote long-term understanding.

The Influence of How Teaching is Valued by Faculty on Teaching Practice

The majority of the subjects believe that faculty in the department generally valued teaching (Figure 4). However, how the faculty value teaching in itself may not promote faculty use of effective teaching practices. There are a number of internal and external factors that influenced and generally determined the individual subject's teaching effectiveness. The major factor that appeared to influence and promote high quality teaching practices was described as an intrinsic motivation to be a good educator. In other words, it was the subject's responsibility to be a good educator because they held the position of (assistant/associate/full) professor.

Several subjects stated that the reward structure was not currently set up to reward quality teaching; rather it appeared to reward contact hours. Obviously, an increased teaching load does not facilitate utilization of more effective teaching practices. However, the majority

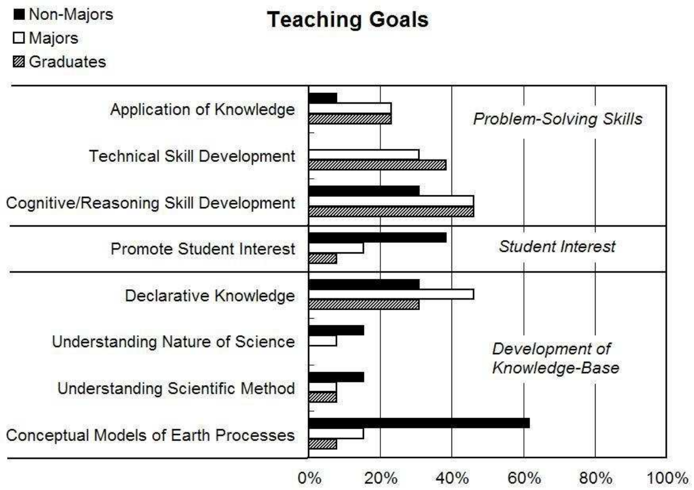


FIGURE 3. Teaching goals of the faculty as a function of the student's academic level. Values reported are the percentage of subjects who spoke to the specific topic.

of the subjects interviewed stated that the reward structure had no impact (45%) on their teaching practice while a smaller fraction indicated that the reward structure had a negative impact on their teaching practice (25%) (Figure 4). Further, research was a fundamental component of the positions, as is expected at a research institute, which was a negative impact on teaching practices implemented by the subjects interviewed. In general, the subjects stated that when extra time was available, it was generally utilized on productivity with regards to research and funding opportunities and not towards innovative teaching practices in the classroom. There appeared to be a general consensus among the assistant professors interviewed that they will be able to focus on teaching after tenure has been achieved.

TABLE 4. AVERAGE M-SCOPS DATA BASED ON ACADEMIC LEVEL[1]

LEVEL	R&D	P&I	
Non-major	4.78±0.069	1.22±0.018	
Major	4.70±0.077	1.30±0.028	
Graduate	4.89±0.140	1.10±0.030	
	Representations students received		
	Symbols	**Objects**	**Pictures**
Non-major	2.88±0.051	0.29±0.020	2.13±0.054
Major	2.91±0.065	0.03±0.004	2.55±0.059
Graduate	3.46±0.110	0.12±0.016	2.90±0.114
	Representations students acted on		
	Symbols	**Objects**	**Pictures**
Non-major	1.54±0.024	0.18±0.012	0.86±0.020
Major	1.64±0.045	0.03±0.004	1.00±0.020
Graduate	1.30±0.047	0.12±0.016	1.12±0.048

[1] Error represents one standard deviation.

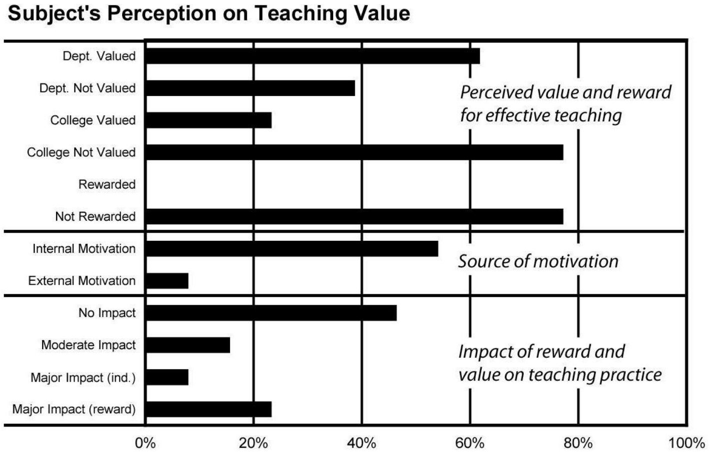


FIGURE 4. Faculty conceptions of the value of teaching. Values reported are the percentage of subjects who spoke to the specific topic.

It is likely that this intrinsic motivation would be the main factor the subjects use to determine which teaching practices they will use in the classroom. However, there are additional factors that may influence teaching methods employed in the classroom. External variables such as class size are an uncontrollable barrier that can greatly influence the teaching practices utilized by the subjects. Student-instructor interaction is inherently more likely in smaller class sizes where facilitation of group discussions can occur more easily. Other variables may influence teaching practices include the level of departmental or institutional support for supplies and other instructive aides.

Influence of Conceptions of Student Development on Teaching Practice

The interview results suggest the subjects' conceive a developmental trend in the ways students learn as the student gains experience in higher education (Figure 1C). Students typically enter school in a "memorization mode" that may fit with the teacher-centered classroom instruction observed in the undergraduate courses. As the student gains experience, they begin to apply that knowledge and as graduate students, learn through practical experience. However, based on classroom observations that showed teacher-centered courses, this progression appears to have minimal influence on teaching practices. The interview data showed a similarity in learning between the subjects and graduate students; the subjects learn best by practice with over 90% responding that this was the method they used to learn (Figure 2A). However, classroom observations also showed teacher-centered instruction in graduate courses. It is possible that faculty may assume that as graduate students, the student is expected to learn through self-directed methods outside of class. In other words, the graduate classes are to provide the background information necessary for self-directed learning. Because the teaching practices are the same for graduate and undergraduate students, it may be possible to reason that undergraduate students are capable of the same, self-directed learning as graduate students. However, motivation levels are conceived to be different and thus place a significant burden to keep the undergraduate students motivated on the instructor. McConnell and others (2003) utilized the studio environment in an introductory Earth Science course and documented improvements on examinations, student retention and logical thinking (cognitive) skills. Completely restructuring a course to a studio learning environment would be a difficult and time-consuming process, especially for faculty at research-focused institutions (Wilson and Jennings, 2000). One simple way to increase student interaction with multiple representations and other manipulatives involves posing a compare/contrast question to a class, having the students share the answer to their "neighbor" classmates and having them defend the answer. M-SCOPS profiles of this activity would indicate higher levels of student interaction and cognitive engagement that would promote student learning.

The subjects generally envisioned a progression in the student's learning methodology from "memorization" mode as new undergraduate students to self-directed learning methods as graduate students. However, based on classroom observations that showed teacher-centered courses, this progression appears to have minimal influence on teaching practices.

IMPLICATIONS FOR PROFESSIONAL DEVELOPMENT PROGRAMS

The master narratives that shape the conversation between American higher education and society generally focus on two main academic activities: (1) universities educate students to have meaningful lives and/or be productive citizens, and (2) universities both serve and challenge society, primarily through academic research that addresses problems of societal significance (Kezar, 2004). These narratives describe the societal role of higher education and are often used to justify the state resources that fund higher education. Unfortunately, funding issues conspire to drive most public institutions away from directly addressing these goals and towards activities that maximize resources such as focusing on the number of students taught or the pursuit of research funding from federal sources. As a result, the values, actions, and reward structures of higher education organizations are not always aligned with these narratives (Jaeger and Thornton, 2006). It is our belief that academic reputations of universities will be built in the coming decade by higher education organizations that can effectively address these narratives while maintaining the high standards of research and teaching recognized by disciplinary communities.

STEM education should lessen its emphasis on didactic, lecture-based modes of instruction and increase its emphasis on learner-centered approaches, such as inquiry-based, problem-based learning, and cooperative learning, as well as an increase in the use of alternative assessment techniques including writing and oral presentations (George et al., 1996; Ireton et al., 1996; Land and Hannafin, 1996; Stout et al., 1994; Barr and Tag, 1995). The observed disconnect between faculty conceptions of student learning and teaching practice was likely rooted in two general factors that influence faculty expertise in effective teaching: the instructors knowledge and skills in teaching practices that promote student learning and a lack of a reward system that supports professional growth (Good, 2004). While the faculty stated that learning was best achieved through practices that promote active student engagement, classroom observations for all academic levels of students showed that teacher-centered practices generally dominated. Professional development programs for both future and current faculty should focused on the knowledge and skills required to be effective teachers, as well as directly address faculty beliefs about the nature of learning that can affect classroom practice (Grappa et al, 2007). In addition, it is important to guide faculty to be reflective practitioners that is guided both by learning theory and evidence of student learning (Davis, 2004; Connolly et al., 2007; Austin et al., 2008). Reflective practice allows faculty to adapt best practices to their specific organization and classroom contexts as well as collect the evidence of their impact on student learning that may provide evidence of teaching excellence that can support tenure and promotion.

The results from this study provide institution-specific baseline data that show instructors' conceptions of student learning have a minimal impact on teaching practices observed in the classroom. However, additional information beyond the classroom may show increased student engagement through homework assignments and course projects that require application of content knowledge rather than just memorizing facts. By gaining a comprehensive understanding of teaching practices, both internal and external to classroom practices, a better path for student-centered teaching practices can be developed.

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