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# A Preliminary Case Study of SCALE Activities at the University of Wisconsin–Madison: Factors Influencing Change Initiatives in STEM Undergraduate Education, Teacher Training, and Partnerships with K–12 Districts

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# A Preliminary Case Study of SCALE Activities at the University of Wisconsin-Madison: Factors Influencing Change Initiatives in STEM Undergraduate Education, Teacher Training, and Partnerships with K–12 Districts

**Matthew T. Hora and Susan B. Millar[1]**

## EXECUTIVE SUMMARY

This report on the SCALE Institutions of Higher Education (IHE) Case Studies line of work provides preliminary findings about SCALE activities at the University of Wisconsin–Madison (UW-Madison). This study focuses on the structural and behavioral dynamics influencing the implementation of the four core SCALE strategies for effecting change in IHEs: (a) reform undergraduate science, technology, engineering and mathematics (STEM) courses; (b) promote collaboration between STEM and education departments regarding pre-service teacher education, (c) promote collaboration between IHEs and K–12 districts regarding in-service professional development; and (d) improve institutional policies and practices at the IHE level that support faculty engaged in pre- and in-service activities. Preliminary findings indicate that SCALE is making progress in each of these areas. Through the Math Masters and Immersion Unit professional development programs for K–12 math and science teachers, SCALE is engaging STEM faculty in learning and modeling inquiry-based pedagogy, which is influencing the faculty's conception of their own teaching and of K–12 issues. Through the co-construction of professional development materials and the co-facilitation of the actual professional development sessions, SCALE is introducing a new, more collaborative and mutually beneficial partnership between UW-Madison and the Madison Metropolitan School District (MMSD). The emerging partnership between the UW-Madison Mathematics Department and MMSD is resulting in greater faculty attention to K–12 issues and in institutional support for the continuation of the Math Masters program from both partner organizations. SCALE is also leading interdepartmental efforts to revise the pre-service math and science curriculum for elementary and middle school teacher candidates.

However, the core SCALE strategies face significant barriers at UW-Madison due to institutional policies and practices that favor research over teaching and service, limit the time available for faculty to participate in SCALE activities, and exacerbate pervasive tensions between STEM and education faculty. Interview respondents frequently used a normative concept of *organizational culture* when explaining how these elements of the UW-Madison structural and social context either precluded or facilitated change. Upon analyzing the data, we found that this normative concept of culture does not adequately model the many different venues in which IHE policies, values, and practices operate and

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the many distinct roles that faculty may play within these venues. A new definition of organizational culture employed in this case study encompasses official policies, such as tenure guidelines, and patterns of beliefs, values, and practices at the institutional, college, departmental, and faculty subculture levels. This research identified indicators of organizational culture that either inhibit or support reform efforts such as SCALE. These indicators will be monitored for the duration of SCALE activities in order to document any changes in policies or practices at UW-Madison and to assess if and how SCALE contributed to these changes.

A preliminary assessment of the approaches to change that SCALE activities are enacting at UW-Madison seems to indicate that instead of radical reform, they are focused on "planting small seeds" of change at various points in the system. Thus far, the key points in the system that we have identified include individual faculty, whose exposure to new pedagogies may bear fruit in later years and in unforeseen ways, and departmental and college-level committees, in which change is a long-term proposition and actors are just now putting in place pieces that they believe will effect change in coming years. For the purposes of evaluation, we note where within the university's organizational structure SCALE actors are choosing to leverage their financial and human resources, and we consider the efficacy of SCALE's particular approach to systemic change for each of its activities. This preliminary phase of the research begins to sketch out the broad outlines of these efforts. Phase 2 of this case study will investigate in greater detail the outcomes and efficacy of these approaches to change.

# A. INTRODUCTION

## System-wide Change for All Learners and Educators (SCALE)

System-wide Change for All Learners and Educators (SCALE) is a comprehensive Mathematics and Science Partnership (MSP) funded from 2003 to 2007 by the National Science Foundation (NSF). SCALE is a systemic reform initiative involving institutions of higher education (IHEs) and K–12 partners to improve math and science teaching and learning throughout the entire educational spectrum. The SCALE theory of change posits that the entire continuum of teacher training and professional development must be improved, with particular attention to improving the role IHE faculty play in designing and implementing pre-service curricula and in-service programs. Through the following four goals, SCALE aims to enable IHEs to better serve future and current K-12 math and science teachers: (a) reform undergraduate science, technology, engineering and mathematics (STEM) courses; (b) promote collaboration between STEM and education departments regarding pre-service teacher education, (c) promote collaboration between IHEs and K–12 districts regarding in-service professional development; and (d) improve institutional policies and practices at the IHE level that support faculty engaged in pre- and in-service activities.

This document, the preliminary report of SCALE activities under way at the UW-Madison, is part of the IHE case studies line of work of the SCALE Research and Evaluation Team. The primary purpose of this line of work is to evaluate SCALE activities at each of the participating IHEs in SCALE: UW-Madison, the California State University, Northridge, and the California State University, Dominguez Hills. The secondary purpose of this research is to assess the efficacy of the SCALE theory of change in different institutional contexts and to identify policies, processes, and strategies that are effective in achieving the goals of SCALE and the MSP program. The research questions addressed in the preliminary IHE case studies are as follows:

1. What factors impede and support the core strategies of SCALE?

2. Are SCALE activities contributing to changes in these areas? If so, how?

3. Under what conditions are change initiatives, including SCALE, accepted and incorporated at UW-Madison?

## Background of the NSF Math and Science Partnerships

While national attention over declining student achievement in math and science often leads to criticism of the K–12 system, increasingly higher education's role in educating undergraduates and future K–12 teachers is being scrutinized (Levine, 2006). Some critics note that many undergraduates of STEM programs have severe deficiencies in their content knowledge (Handelsman et al., 2004). Curricula designed for pre-service teacher candidates are also commonly criticized as being poorly designed and insufficiently grounded in rigorous content courses and/or pedagogical instruction (Mundry, Spector, Stiles, & Loucks-Horsley, 1999). This has led NSF to focus—through its Mathematics and Science Partnership (MSP) program, among others—on fostering improvement in undergraduate STEM courses and pre- and in-service teacher preparation programs offered by IHEs.

Critiques of the quality of teaching in higher education began in the 1980s with the publication of *A Nation at Risk* (National Commission on Excellence in Education, 1983). Since then, we have seen a cascade of criticisms of higher education, culminating in the just released report of the U.S. Department of Education, *A Test of Leadership: Charting the Future of U.S. Higher Education* (2006). These critiques are spurred in part by declining student achievement in math and science at the K–12 level, a national shortage of undergraduate math and science majors, and a "chronic and growing shortage of discipline-qualified mathematics and science teachers in the K–12 system" (Seymour, 2001, p. 83; see also U.S. Department of Education, 2005). The criticisms focus on issues ranging from the poor quality of undergraduate education, to the increasing costs of IHEs and the related decline in student diversity, to the lack of systems for assessing student learning. In response to these systemic challenges that affect the entire K–20 educational continuum, critics, education reformers, and government agencies are increasingly focusing on K–12 teacher training in pre-service programs at IHEs and on IHE participation in in-service professional development (U.S. Department of Education, 2005).

Indeed, some analysts have found that current teacher training "that is a mile wide and an inch deep," and in-service professional development programs that do not build on novice teachers' prior experiences or knowledge, may do more harm than good (Mundry et al., 1999). Contributing to deficiencies in these programs is the lack of alignment among the parties responsible for training math and science K–12 teachers—specifically, between STEM and school of education faculty at the IHE level, as well as between district administrators and math and science coordinators at the K–12 level. As a result, future math and science teachers who traverse this educational curriculum must navigate three distinct institutional settings, each of which has its own problems: (a) school of education teacher preparation programs, (b) STEM undergraduate departments, and (c) professional development offered through K–12 districts.

In 1998, the National Research Council addressed this multi-institutional problem by establishing a Committee on Science and Mathematics Teacher Preparation (CSMTP). The CSMTP report (2001) argued for a significant restructuring of the relationship between K–12 schooling and higher education, including new partnerships to collaboratively design and implement high-quality professional development programs. The CSMTP also urged greater collaboration across departments and colleges within an IHE with respect to improving teacher preparation, increasing STEM faculty understanding of K–12 education, restructuring undergraduate STEM courses to promote active learning, and revising IHE reward systems to prioritize teaching and service activities. The *Shaping the Future* report by the National Science Foundation (1996) further stated that by using active learning strategies in their undergraduate courses, STEM faculty not only help their students understand discipline content more deeply but also model effective pedagogy that future teachers can use in their own instruction.

Such critiques and issues are among the reasons NSF has invested substantially in teaching improvement and organizational change in higher education. The MSP program is one of several current NSF programs emphasizing the shift from the traditional view that math and science education should be available to a small proportion of the most able students, to a more inclusive vision of math and science education called *science for all*. One of the desired outcomes of the shift to *science for all* is to reform and align the entire educational spectrum, by shifting educators' pedagogical orientation to active learning, redefining and rewarding teaching and education scholarship, rethinking IHE relationships with K–12, and restructuring professional education and development (Seymour, 2001).

Yet change in the IHE sector is an extremely difficult undertaking that has been variously described as "glacial" and "tinkering around the edges" (Cuban, 2000, p. 16). Researchers cite the persistence and resiliency of institutional tradition (Kezar & Eckel, 2002), the decentralized and loosely coupled nature of IHEs (Birnbaum, 1988), and the unique elements of organizational structures and cultures (Schroeder, 2001) as characteristics of IHEs that make them resistant to change. For example, historical divisions between STEM and education faculty may inhibit interdepartmental collaboration (Labaree, 2004) and contribute to STEM faculty distrust of research findings about improved pedagogies that come from "suspect" fields such as education research (Handelsman et al., 2004). In addition, changing the relationship between IHEs and K–12 is problematic due to a historical divide between these two educational systems that often is described as characterized by "widespread misperceptions and turf battles" (Gilroy, 2003, p. 26). These are the institutional and historical contexts in which SCALE is operating at UW-Madison.

## Methodology

The qualitative case study approach is a methodology for conducting an empirical inquiry into a "contemporary phenomenon within its real life context, especially when the boundaries between phenomenon and context are not clearly evident" (Stake, 1994, p. 13). The IHE case studies clearly meet this criterion, and since the evaluation of SCALE activities is focused on change processes, the descriptive and exploratory nature of qualitative case study research is particularly appropriate (Merriam, 1998). The boundary of this case study is the UW-Madison, with a focus on the smaller organizational units of the School of Education and individual STEM departments.

The case study is being conducted in two phases of data collection and analysis. Phase 1 is a formative evaluation of SCALE activities and a preliminary assessment of the organizational context of UW-Madison and the key issues, trends, and themes facing SCALE. This document reports on Phase 1 of the research. Phase 2 of the research will build upon the findings in Phase 1 to focus on the key issues, trends, and themes through more targeted data collection and analysis. Phase 2 will also include a summative assessment of SCALE's impact at UW-Madison. The three types of data collected include semi-structured interviews, observations of meetings and conferences, and university documents.

## *Data Collection*

### *Semi-Structured Interviews*

We interviewed 18 faculty, academic staff, and administrators at UW-Madison using a semi-structured interview protocol to obtain systematic and complex qualitative information about change at various organizational levels. In addition, we analyzed six interviews of administrators, staff, and teachers from the Madison Metropolitan School District (MMSD) that were conducted for a related SCALE research project (Building a Partnership). The sampling method employed in this case study was the snowball sample, in which informants suggested other individuals who would be of value to the research. While most respondents were participants in SCALE and other similar reform projects, we also sought out and interviewed respondents with no involvement in these efforts.

For Phase 2 of the research, we will conduct 24 new interviews and will analyze many relevant interviews from the Building a Partnership line of work. Some of the 24 new IHE case study interviews will be with SCALE participants interviewed in Phase 1, and others will be with new faculty, academic staff, and administrators who have no involvement in reform efforts. This design is intended to accomplish two goals: (a) to assess the impact of SCALE on individual IHE participants by interviewing these participants at two points in time; and (b) to assess the organizational climate among different STEM and education departments by interviewing a sample of faculty, staff, and administrators not involved in reform efforts.

### *Observations of Meetings and Conferences*

We observed a few meetings, seminars, and workshops at UW-Madison pertaining to the research questions in order to obtain a firsthand understanding of the nature of reform efforts on campus. For Phase 1, a campus-wide Teaching and Learning Symposium, workshops on STEM reform efforts, and interdepartmental meetings about curriculum revision were observed.

### *Document Review*

We collected and analyzed official and unofficial university documents, reports, and literature relevant to the research question.

## *Analysis*

We used a grounded theory approach to analyze the interview, observation, and documentary data. In this case, while the research questions and the interviewer’s personal style certainly dictated the type and quality of data collected, there were no *a priori* assumptions of key themes or theoretical frameworks for the analysis. At this early stage of data collection, a literature review was conducted that provided some basic information about teacher education and higher education, but generally, the lack of a literature on the specific research topic underscored the value of a grounded approach.

We began the work of identifying themes in the data by analyzing the transcriptions of the 24 in-depth interviews, which were entered into a qualitative data analysis software program. The interviews were coded using an emergent coding tree, in which recurring themes and patterns were coded “in-vivo” as they emerged. Themes were identified based on their numerical occurrence, topical relevance, and respondent-identified importance (Ryan & Bernard, 2003). We then used the constant comparative method of analysis to assess the validity of the emerging findings. The key themes were cross-checked with data from the collected documents and observation notes. This step enabled triangulation across different types of data sources. It also allowed for the inclusion of different perspectives and information about the themes, in order to flesh out the interview data with documentary evidence and observation-based corroboration. Extensive notes were taken to document this analytic process so that the chain of evidence could be established regarding the conclusions of the research.

### *Limitations*

The IHE faculty and MMSD staff interviewed for this research do not constitute a random or representative sample of UW-Madison overall or of individual UW-Madison colleges or academic departments. This is due to the purposive nature of the sampling process and the relatively small number of individuals interviewed. While this is a limitation, it is not a problem because this research is not intended to be generalizable. Rather, it is intended as an exploratory review of STEM and education department sentiments and an investigation into the initial impact of SCALE activities. An additional limitation to this study is that the findings are largely based on respondents’ self-reported behaviors, which have not been verified with classroom observations or other data on individuals’ actual teaching approaches or behaviors.

## B. INSTITUTIONAL CONTEXT: UW-MADISON

This section provides a brief overview of key characteristics of UW-Madison as an institution and the ways in which some of these influence SCALE operations. Material is this section is drawn from respondent perspectives, document analysis, and a review of the higher education literature. Some of these characteristics are addressed in greater detail in later sections.

### History and Overview

Founded in 1848, UW-Madison is the flagship institution for the 13-campus University of Wisconsin System. It is located in the state capital, the second largest city in Wisconsin (population 208,054 in 2004). With an enrollment in the fall of 2004 of 41,169 students, including 28,217 undergraduates and 8,943 graduate students, UW-Madison is one of the largest public universities in the nation (http://www.wisc.edu/about/facts/). The university has an annual total budget of $1.8 billion yet operates in a climate of declining financial support from the state of Wisconsin and increased public scrutiny over its finances.

UW-Madison is a designated land-grant university and is located in one of the most productive agricultural regions of the country. One of the missions of land-grant universities is to teach agriculture and provide working-class residents of the state with a solid and affordable liberal arts education. This mission led in part to the development of the "Wisconsin Idea," a tradition begun by UW President Charles Van Hise in 1904, who stated that he "would never be content until the beneficent influence of the university reaches every family in the state" (http://www.wisc.edu/wisconsinIdea/). The current strategic plan also asserts that the university aims to "vigorously share advances in science and knowledge with the people of the state, the country, and the world" and "to expand university-state relationships in a way that reflects the new global economy" (http://www.chancellor.wisc.edu/strategicplan/).

## Institutional Characteristics

According to the Carnegie Foundation's influential ranking of IHEs, UW-Madison was formerly classified as a Research I institution and now is categorized as a Research University with very high research activity (RU/VH) (Carnegie Foundation for the Advancement of Teaching, 2006). The Research I moniker will be used throughout this report due to its pervasive usage by IHE faculty and administrators. This ranking is considered prestigious and indicative of a topflight university with active research programs, highly ranked departments, and internationally recognized faculty. According to the Lombardi Program on Measuring University Performance (Lombardi, Capaldi, Mirka, & Abbey, 2005), in 2003 UW-Madison was ranked 4$^{th}$ in total research funding, 8$^{th}$ in federal research funding, and 7$^{th}$ in doctorates granted.

In addition, 5 Nobel Prizes have been awarded to current or former faculty, 17 Pulitzer Prizes have been awarded to faculty and alumni, and 58 faculty are members of the National Academy of Science or the National Academy of Engineering (http://www.chem.wisc.edu/about/overview.php). Notably, several graduate programs at UW-Madison are highly ranked, including the School of Education and the Departments of Biochemistry, Molecular Biology, Plant Pathology, Oncology, Chemistry, and Chemical Engineering (http://www.genetics.wisc.edu/programs/grad/brochure.html#uw; U.S. News & World Report, 2007). In addition, UW-Madison hosts several internationally recognized research centers, including the Biotechnology Center, the Space Science and Engineering Center, and the Wisconsin Center for Education Research.

Respondents saw the shared conception of UW-Madison as a prestigious research-oriented institution as a pervasive influence at the university and as the primary institutional identity and raison d'être for the STEM disciplines, among others. This view is echoed in the university mission "to create, integrate, transfer, and apply knowledge" with the objective to "sustain and strengthen our position of preeminence in research and higher education" (http://www.chancellor.wisc.edu/strategicplan). In order to maintain and further develop the prestige of the institution, the university is focused on attracting the best graduate students, faculty, and researchers; receiving increasingly large amounts of private and public funds; and achieving high rankings in publications such as *U.S. News & World Report* (Hutchens, 1998). Several respondents noted the contradiction between the two core elements of the university's institutional identity—that of a Research I institution and that of a land-grant university inspired by the Wisconsin Idea.

## Governance and the Academic Department

Leadership at UW-Madison is a system of distributed power and authority, in which there are "no magic wands, and few carrots or sticks are held at the central levels," and in which the real authority lies with departments and colleges (Rouse & Sapiro, 2005). The upper administration consists of a chancellor (who is considered the CEO of the university), a provost and vice chancellors, and 15 deans of various schools and colleges. Authority is frequently devolved from the institutional and college level to departments, where decisions are ultimately made regarding tenure guidelines, assessment procedures, and the academic program.

The role of the department is immensely important in shaping the organizational context of SCALE operations, as the policies, shared behaviors and practices, and personalities of individual faculty and staff together constitute a professional environment that exerts significant pressure on individual faculty behaviors and practices. As a respondent noted, "Every discipline carries with it its own way of thinking," and attention to the unique practices, terminology, and sociocultural aspects of different disciplines is important. Here, as at all research institutions, disciplinary assumptions about epistemology, methodology, and professional identity are fostered during a student's introduction to a disciplinary community (Kuhn, 1970). Once scholars have achieved status as a full member in their field, they are sustained by communities of practice with common interests. If they become faculty, they then acquire an intellectual home in the university department, which, according to Schneider and Shoenberg (1999), is a necessity in any complex institution such as an IHE.

One respondent succinctly summarized the role of the academic department at UW-Madison by highlighting the importance of autonomy and decentralized governance at UW-Madison and explaining how these play out at the departmental level, and how the leadership of the chair may not be particularly influential:

> Well, our department and pretty much the university at large doesn't really believe in leadership. We have this tradition that's called faculty governance. So it basically means that everything is decided from the bottom up. It's all committee-driven and everything is processed. The up side of this is that it really helps people get along, and [helps] with morale and makes people feel like they are involved. But it's monumentally an inefficient way to accomplish anything. It's just the way things are done around here. (Math faculty)

The critical role that departments play is further accentuated by the cherished tradition of faculty autonomy. Faculty are vested with responsibility for "immediate governance of the university" and have "primary responsibility for academic and educational activities and for faculty personnel matters," including educational policies, establishment of faculty committees, requirements for admission, requirements for graduation, adoption of rules for recruitment and performance reviews (http://www.secfac.wisc.edu/governance/FPP/Chapter_1.htm).

## Recruitment, Tenure, and Promotion Guidelines

Faculty life is characterized by attention to the reward and promotion system within departments, also known as recruitment, tenure, and promotion policies (RTP). Even after achieving tenure, faculty are subject to promotion policies and must pay attention to departmental needs. For this case study, we reviewed the tenure and promotion guidelines for the Division of Biological Sciences and the Division of Physical Sciences at UW-Madison, paying particular attention to the role of teaching, use of education research, and role of community service. Apparently, the tenure guidelines in all four UW-Madison faculty divisions were recently rewritten to emphasize teaching, grant sabbaticals to accomplish teaching goals, and require departments to base at least 20% of merit-based salary increases on teaching (Handelsman et al., 2004). The rationale for this change will be investigated in greater detail in Phase 2 of this case study.

Generally, each faculty division is focused on hiring and promoting individuals with national or international reputations who will be involved in "improving the academic and professional quality of the department" (http://www.secfac.wisc.edu/governance/FPP/Chapter_7.htm). The three primary criteria for achieving tenure in each division are research, teaching, and service. Research is described as an active research program that has "yielded demonstrably significant results," as evidenced by publications, and evidence of external funding to ensure the viability of the research program is highly valued. Teaching is measured by peer review (at the discretion of the department) and student evaluations. The Division of Physical Sciences is especially interested in evidence of continued development of teaching skills and improvement and modernization of courses over time. Service is a very broad construct and includes participation in departmental or university committees, professional organizations, government agencies, or professional consultation to the community.

Each division notes that all three areas should be evaluated when considering a tenure review and that candidates should be well balanced in these areas. However, each division includes provisions for evaluating candidates based on different configurations of experience. For example, the Division of Physical Sciences allows recommendations based primarily on research, scholarship in education, or work in outreach/extension. In each of these cases, if the review focuses on one area, the candidate must be "one of the very best in the field in his/her peer group," and for teaching, the "impact of the candidate's contribution to teaching must extend beyond the campus." It is clearly stated that service alone is insufficient for tenure or promotion.

## Faculty Life

Faculty at UW-Madison are generally involved in two major activities, research and teaching, and to a lesser degree, professional or community service. In a Research I institution, naturally the focus is on research, and faculty have varying degrees of research activities, some with several different projects and millions of dollars, and others with very few. Teaching responsibilities are established by each department and also vary based on tenure and social status. They differ in format as well, from undergraduate courses with up to 400 students to 8-student graduate seminars. Faculty with research projects that involve post-docs, graduate, or undergraduate students also consider themselves involved in training activities, which are another time-consuming responsibility.

Efforts to improve STEM undergraduate education and promote K–12 partnerships should be understood in the larger context of the widespread perception by faculty that their professional lives are overwhelmingly busy with research, teaching, and service responsibilities (Rouse & Sapiro, 2005; Millar, Clifford, & Connolly, 2004). From the point of view of individual faculty, different groups and offices on campus are constantly asking them to do more, including improving student assessments, using new technology, being more interdisciplinary, and focusing on classroom climate (Rouse & Sapiro, 2005). A recent needs assessment corroborated these perspectives on faculty life in UW-Madison STEM departments (Millar et al., 2004) and presented the following as dominant characteristics of academic life at UW-Madison:

- Teaching and research as two distinct activities;
- Greater value accorded to research than to teaching by academic colleagues;
- Teaching and research as solitary pursuits; and
- Lack of time.

## Structure of UW-Madison Teacher Preparation Programs

The elementary and secondary teacher education programs at UW-Madison are administered by the School of Education. The school is one of the top-rated colleges of education in the country, particularly its curriculum and instruction, educational psychology, and educational administration programs. The school offers teacher education programs in more than 30 subject areas, each of which requires 4 years of coursework. In the fall of 2005, the elementary education program enrolled 450 students; secondary math, 28 students; and secondary science, 29 students. For the academic year 2004–05, 137 degrees were awarded to elementary education majors, 21 to secondary math majors, and 25 to secondary science majors. During that same period, approximately the same number of teaching licenses were signed for each major (UW-Madison School of Education, personal communication, 2006).

### *Elementary Education*

The elementary education program has two options: the early childhood/middle childhood option prepares teachers to work at preschool, primary, and intermediate levels, and the middle childhood/early adolescence option prepares teachers for intermediate and middle school levels. Each option includes liberal studies courses, coursework in a focus area, education coursework, and a professional sequence. Also, a dedicated sequence of courses provided by the Department of Mathematics is required for elementary pre-service candidates. This sequence, called the *13X sequence*, includes courses called Mathematics for Elementary Teachers, Arithmetical Problem Solving, and Geometrical Inference and Reasoning.

### *Secondary Education*

The secondary science and math programs require majors in the disciplinary field and additional methods or pedagogy coursework in the Department of Curriculum and Instruction. Options for the secondary science major include broad field science, biology, chemistry, earth and space science, or physics. The broad field science degree option is attractive because it permits individuals to teach courses in middle and high school that are not specific to a particular science field, with titles such as Life Science and General Science.

## K–12 Outreach

Involvement with K–12 education at UW-Madison has historically been through outreach programs (such as UW-Extension), recruitment efforts, campus-wide initiatives to engage the community in implementing the Wisconsin Idea, or, most commonly, interactions between individual faculty and individual schools or teachers. These latter efforts involve IHE faculty in conducting demonstrations or field days at schools or public events, inviting K–12 students and teachers to participate in research activities, or conducting education research in individual classrooms or schools. Currently, a driving force behind such interactions is the *broader impacts* criterion for NSF grant proposals. This criterion, introduced in 1997, stipulates that as a condition for receiving federal funding, the grantee will conduct some activities that will have “broader impacts” on society (http://www.nsf.gov/pubs/gpg/broaderimpacts.pdf).

Outreach programs at UW-Madison include the School of Education’s Office of Education Outreach, which sponsors professional development and certificate programs for K–12 teachers.  A few of the many other institutionalized programs that involve K–12 are listed below. This list, which is not intended to be exhaustive, illustrates the types of programs in place at UW-Madison. It is important to note that faculty can engage in collaborations with K–12 districts and/or teachers through different types of institutional venues, such as initiatives supported by departments or research centers.

- The *Science Alliance* is a loose coalition, most of whose members are working in science outreach at UW-Madison, that “helps science outreach programs at UW-Madison to synergize their work and to make it easier for the public to find and use the people, facilities and other scientific resources on campus.”

- The *Office of Space Science Education* holds summer workshops for high school students, convenes K–12 professional development programs, and develops K–12 educational materials and tools.

- The *Center for Biology Education*, part of the Institute for Cross-college Biology Education within the College of Agriculture and Life Sciences, develops and coordinates research programs for K–12 teachers, and professional development for K-12 teachers and UW-Madison faculty, such as interdisciplinary brown bags and teaching improvement workshops.

- The *Institute for Chemical Education* is a national center housed in the Department of Chemistry that develops K–12 curriculum, publishes the *Journal of Chemical Education*, and conducts professional development programs.

- *BioTrek*, the science outreach program of the Biotechnology Center of UW-Madison and of UW-Extension, provides workshops and in-service training for K–12 teachers and students.

## Institutional Change and Education Reform

**The degree to which reform efforts such as SCALE are influencing the core elements of the policies and practices at UW-Madison, or are marginalized to peripheral reform initiatives, is a significant question.**

Institutional change initiatives pertaining to the education mission are a part of the institutional history at UW-Madison and date as far back as the activities of Dr. Meikeljohn, who created a revolutionary "learning community" in 1927. Education change initiatives are currently occurring throughout the entire university at campus, departmental, and individual faculty levels, yet they are loosely coordinated, if at all. It is of note that many of these initiatives are funded by external sources such as NSF and are not internally directed. The longevity and efficacy of such externally funded change initiatives have been questioned (Tobias, 1992). However, UW-Madison is nationally recognized as having visible and prominent teaching and learning initiatives that some believe indicate an institutional commitment to improving undergraduate education (Fogg, 2006). The degree to which these reform efforts influence the core policies and practices at UW-Madison or operate only on the periphery is a significant question. Phase 2 of this case study will further investigate this question, focusing particularly on the degree to which the academic department, which is the strongest organizational unit at UW-Madison, is affected by reform efforts like SCALE.

As it is not feasible to list all of the historical and active education reform programs, only initiatives (in addition to SCALE) that were frequently mentioned by interview respondents are introduced briefly below.

- *Annual UW-Madison Teaching and Learning Symposium*: This annual symposium is sponsored in part by the Office of the Provost. It enables the associate vice chancellor for teaching and learning to showcase many of the university's initiatives to improve the quality of teaching at UW-Madison, particularly at the undergraduate level.

- *KTI (K-Through-Infinity)*: KTI was an NSF-funded initiative to provide fellowships and training for graduate students to improve K–12 STEM education. KTI was an immediate precursor to SCALE.

- *CIRTL (Center for the Integration of Research, Teaching, and Learning)*: CIRTL is an NSF-funded initiative to promote the development of a national faculty in STEM committed to implementing and advancing effective teaching practices for diverse student audiences as part of their professional careers.

While some education reform efforts (CIRTL and KTI) are widely recognized and even prominently displayed in the campus Strategic Plan (http://www.chancellor.wisc.edu/strategicplan), most operate on their own in disparate parts of the institution. One respondent described the university as a large and dynamic organism that is influenced by these relatively small change efforts in often imperceptible but powerful ways.

> The university is quite dynamic. It just has some fundamental rhythms. Those rhythms are not much affected by point charges, even if they're large, $10 million point charges, like CIRTL. But if you start to get the "pings" in unison and you do it long enough, you can start to change, I think, the fundamental modalities by which this organism, this complex dynamic organism, vibrates. So I think for anything like a Research I, or even K–12 education, if you don't take a long view, you're going to not be real satisfied. (Math faculty)

Theories of institutional change such as this were voiced by several respondents and will be investigated later in this case study. A respondent who holds an administrative position on campus reported a gradual change in the university, due in large part to "lots of pedagogy projects," which in turn were contributing to an institutional climate of improvements in teaching and active learning. This respondent also encouraged taking a long view of institutional change at UW-Madison and noted the difficulty in assessing and evaluating the impacts of projects like SCALE.

## C. SCALE CHANGE INITIATIVES

This section describes the three primary activities of SCALE, assesses their goals and objectives, and considers issues related to their institutionalization.

### Overview of SCALE

At the beginning of the SCALE MSP, while the larger goals for IHE involvement and outcomes were clear, the specific objectives and strategies for achieving those goals at UW-Madison were not. In fact, some of the strategies described in this section have only recently been initiated and, because they are developed "on the fly" as opportunities present themselves, cannot be assessed in terms of carefully designed plans and theories of action. This approach is known as the "campaign approach to change," which involves mobilizing people around a strategic theme that has staying power at a particular institution (Hirschhorn & May, 2000). The strength of this approach is that the main actors involved in SCALE at UW-Madison are able to identify strategic opportunities for leveraging resources. These may include combining resources with other change efforts or institutions to achieve like goals, or seizing an opportunity, such as the appointment of a sympathetic new departmental chair or dean, to promote a reform agenda. This approach also presents a number of challenges. In particular, leaders must (a) have a deep understanding of the institutions involved and extensive collegial networks that enable them to constantly obtain information about new developments that may provide high-leverage opportunities for change; (b) constantly adjust to the changing situations facing their K–12 and IHE partners; and (c) be careful not to get too far out in front of others to allow for consultation and co-development processes. In addition, leaders may find it difficult to know if and when a project is meeting its own criteria for success because goals, objectives, and strategies are not clearly stated prior to implementation.

### *SCALE Theory of Change Regarding IHEs*

The SCALE theory of change is based on a systemic understanding of the educational systems that inform and support K–20 math and science education. With respect to IHEs, this theory holds that if improvements in IHE participation in teacher preparation and professional development are to be sustainable and significant, then it is necessary that:

1. STEM faculty improve their approaches to teaching and learning;
2. STEM and education faculty collaborate effectively to improve teacher preparation; and,
3. Leaders at different levels of the institution work to overcome the conservative nature of the IHE by supporting faculty participation in teacher preparation.

**Instead of trying to enact radical reform, SCALE is focused on "planting small seeds" of change at various points in the UW-Madison system, particularly at the individual faculty and the college committee levels.**

While this formulation of a change theory specifically targets IHE actors and venues, it is worth considering the broader theory of change held by IHE actors generally, as well as by SCALE leaders. Since IHEs, and particularly large decentralized institutions such as UW-Madison, are notoriously resistant to change, it is not realistic to expect SCALE to effect a radical sea change throughout the entire institution. One respondent observed that, even if the provost or chancellor decided to implement significant reforms, most likely little would change because departments would go on as usual. In fact, a preliminary assessment suggests that SCALE leaders are using the following implicit theory of change at UW-Madison: "plant small seeds of change at points in the system deemed most likely to eventually yield large changes, and do so by building on and collaborating with other change initiatives (at UW and other institutions) that complement SCALE goals, and by identifying and working with individuals already interested in these goals." Thus far, the key points in the system that we have identified include individual faculty, whose exposure to new pedagogies may bear fruit in later years and in unforeseen ways, and department- and college-level committees, in which change is a long-term proposition and actors are just now putting in place pieces that they believe will effect change in coming years. For the purposes of evaluation, we note where within the university's organizational structure SCALE actors are choosing to leverage their financial and human resources, and we consider the efficacy of SCALE's particular approach to systemic change for each of its activities. This preliminary phase of the research begins to sketch out the broad outlines of these efforts. Phase 2 of this case study will investigate in greater detail the outcomes and efficacy of these approaches to change.

### *Criteria for Inclusion and Attribution Issues*

The programs described below are joint and/or collaborative ventures to which SCALE has contributed significant staff time, funding resources, and leverage to accomplish shared goals. In each case, SCALE is playing a leading role in designing and instituting the programs.

We note that SCALE's collaborative approach to change entails an additional issue related to evaluation. Since SCALE activities at UW-Madison are conducted in partnership with other institutions or organizations, it is not feasible to identify where the effect of one partner or program begins and ends. It is also worth noting that SCALE administrators have a long-term view of their goals and recognize that changing faculty behaviors and the institutional context that supports them is a difficult challenge. However, the specific contributions of SCALE and its partners are delineated in the discussion that follows whenever possible. Phase 2 of the UW-Madison case study will further investigate the specific nature of SCALE's role in changes observed at institutional levels, ranging from individuals to the institution as a whole.

Finally, it is important to note that two of the programs outlined below, Math Masters and Science Immersion Units, address the SCALE goal of improving the understanding and appreciation of IHE faculty for K–12 education. As a result, many of the initial outcomes described for each project, and challenges facing their eventual success, are interchangeable. A specific project is named when outcomes or challenges relate only to that project. Otherwise, the effects are simply attributed to "SCALE."

## Math Masters

### *General Overview*

Math Masters is a professional development program for MMSD math teachers focused on content-based enhancement of K–12 teachers' mathematics knowledge. Math Masters is specifically designed to support the implementation of a research-based mathematics curriculum—Connected Mathematics Project (CMP)—that is being implemented in MMSD and two nearby districts. SCALE leaders developed the initial Math Masters project (2004–05) in response to student learning and teacher training needs identified and documented through a needs assessment conducted by the project partners. In 2004–05, with a one-year state-administered U.S. Department of Education (Title IIB) grant, UW-Madison mathematics professors and MMSD math educators collaborated to teach one-credit (20-hour) courses. These courses focused on five of the "big ideas" in middle school mathematics (number operations, geometry, measurement, algebra, statistics and probability) and on the ways in which students learn that content. In addition, MMSD leaders offered optional, parallel one-credit courses in pedagogy. A second Title IIB Math Masters award (2005–06) enabled this group to provide six 2-credit courses centered both on content and pedagogy. Math Masters sessions are designed and taught by teams of UW-Madison STEM faculty and MMSD math resource teachers.

### *Assessment of Program Goals and Objectives*

The goal of the Math Masters project is to expand K–12 teachers' subject matter knowledge of deep mathematics linked to state and national standards. The Title IIB proposal writers articulated three objectives for achieving this goal: use of classroom observations, provision of in-class support, and use of reflective analysis. They also clearly articulated strategies for achieving these objectives, which they closely linked to MMSD practices and objectives for teaching and learning. Key among these strategies is that UW mathematics professors should model constructivist approaches and differentiation in Math Masters courses so that "teachers experience firsthand, as learners, the instructional approaches they will be using with their own students" (Math Masters proposal). This said, the proposal writers were less specific about the goals and objectives for the STEM faculty who were to be involved. An implied objective was that, through co-facilitating the workshops, the STEM faculty would learn about, and learn to model, the active learning pedagogies required for teaching the Connected Math curriculum. Thus, while the primary and explicit goal of Math Masters is professional development of K–12 math teachers, the program is also designed to provide informal professional development for STEM faculty, in the hopes that they will institute a content-based pedagogical approach in their own undergraduate courses.

The IHE SCALE leaders also stated in the proposal that a spin-off goal of Math Masters was to build the capacity of UW-Madison to "offer appropriate content-based courses to both pre- and in-service middle school mathematics teachers." However, they did not make specific the objectives and strategies they would use to accomplish this goal. Ideas about strategies are just now being articulated and developed. Phase 2 of this case study will further investigate this issue.

### *Initial Outcomes*

Because the IHE case studies focus on outcomes related to IHE faculty and institutional policies, we mention only briefly outcomes for K–12 participants and then turn to IHE-focused outcomes.

#### *Evaluation Findings Indicate Learning for K–12 Teachers*

In the first year (2004–05) of Math Masters, 58 middle school teachers took one or more of the five content-related courses and three pedagogy courses that the Math Masters project offered. Pre- and post-test results showed that participating teachers had statistically significant gains in all five content courses. Each course enhanced teachers' learning, with effect sizes ranging from .58 to .91. Qualitative data from both the content and the pedagogy courses indicate that the courses met teacher participants' goals and that teachers learned both important math content and related instructional strategies. In addition, some case study respondents reported that an accomplishment of the program was that it enabled many K–12 teachers to stop feeling intimidated by math professors. Others emphasized that an even more important outcome of Math Masters was that it helped teachers feel confident in their understanding of math content.

### *Math Masters and the Science Immersion Units Are Changing the Model of IHE/K–12 Partnerships Between UW-Madison and MMSD*

Several respondents noted that SCALE, through the Math Masters program and the Science Immersion Units, established a more collaborative and mutually enriching relationship between IHE and K–12 than previously experienced. K–12 personnel indicated that it was refreshing that IHE faculty came to the K–12 venue with professional development materials tailored to K–12 participants' unique needs and constraints.

> It used to be [that] we'd have the university comin' after us for everything under the [sun] . . . This person has an interest in that, this person has an interest in that, and "Let's do this cute little thing and that cute little thing." And that still happens to some extent. But with SCALE, we now have at least some people at the university who understand that, unlike the university, the district is, in fact, a system. And that it has goals for kids that are very, very specific. And that we are standards-based, [although] I don't know if they understand the standards yet. But [they understand that] we're trying to move everybody in the same direction and that [university people] get in the way when they just take a shot in the dark." (MMSD personnel)

Another facet of this more substantive and responsive type of collaboration is the reported willingness of IHE faculty to immerse themselves in the pedagogy of the professional development sessions. We learned from both K–12 and IHE respondents that in the case of Math Masters, the SCALE IHE faculty were becoming learners and momentarily bridging the gap between content and pedagogy that characterizes many debates and divisions about curriculum at all levels.

### *Math Masters Is Fostering a New Type of Partnership*

One of the characteristics of previous UW-Madison and MMSD partnerships, as experienced by many of the MMSD respondents, is that IHE faculty behaved with arrogance and condescension towards K–12 education and showed little insight into K–12 needs. The SCALE partnership appears to be forging a different type of relationship. For example, one K–12 respondent noted that an immediate benefit of Math Masters is a larger pool of STEM faculty who are respectful of and responsive to K–12 needs and who may provide MMSD teachers with access to facilities, experience with cutting-edge research, and pedagogical training.

One outgrowth of the Math Masters project is that MMSD personnel now have an unprecedented level of access to some STEM departments at UW-Madison, particularly the Mathematics Department. An example of this access is the co-teaching of a lower division mathematics course designed for pre-service elementary teachers by a math faculty member and an MMSD teacher. This MMSD teacher also serves on an interdepartmental committee that is revising the pre-service curriculum for middle school math teachers at UW-Madison. Compared to past practices, this development represents a remarkable level of participation by a K–12 teacher in matters of IHE curriculum development.

### *Some STEM Faculty Learned Firsthand About Constructivist Pedagogies*

A faculty member interested in learning about the Connected Math program noticed that the word *content* was in the Math Masters proposal and commented that he got involved because this proposal was "the first I'd seen that was addressing an issue that I think is important." This faculty member further explained,

> I'm not very interested in the latest fad in methodology. So I knew that I would be teaching within the framework of Connected Math, at least in part. And I thought that it would be enlightening to actually see what the teachers I was teaching thought about this stuff, what worked and what didn't, how efficient it was, and all this kind of thing. So it's been very interesting. (Math faculty)

### *Participating STEM Faculty Developed a New Perspective on K–12 Curriculum*

Some faculty expressed great respect and admiration for the MMSD math educators and teachers with whom they co-designed and implemented the Math Masters sessions. These faculty particularly admired these instructors' ability to adequately teach the Connected Math curriculum, which some respondents felt was quite difficult compared to the traditional approach. In fact, some felt that this curriculum demands training and expertise that are "an order magnitude greater" than those demanded by traditional curricula, which means that poorly trained teachers will be very ineffective at implementing Connected Math. Some respondents noted that this new understanding reinforced their conviction that continuing professional development for MMSD math teachers is critical.

### *SCALE Is Improving STEM Faculty Understanding of K–12*

As previously mentioned, IHE faculty have a tendency to approach K–12 partners in a condescending manner, which has bred a certain degree of distrust over time. One of the goals of SCALE is to address this problem by improving STEM faculty's understanding of the K–12 context so that they can better understand the nature of the K–20 educational continuum and recognize that each party is working on different pieces of the same puzzle. Some respondents directly spoke to this goal. They expressed newfound understanding of the K–12 environment based on their participation in SCALE. In particular, they noted that they had come to understand that a mutually enriching partnership between IHEs and K–12 largely depends on the willingness of each party to understand the unique needs, constraints, and institutional contexts of their partners.

Respondents also identified that many IHE faculty consider K–12 instruction to be "kid's stuff" and indicated that this sentiment is a major barrier to effective partnerships. Through participation in SCALE activities, an MMSD instructor observed in IHE faculty a growing understanding of and admiration for K–12. IHE participants corroborated this observation. Another impact of SCALE is that IHE faculty expressed new understanding that divisions between these two levels of education may be due not simply to the level of sophistication or technical jargon, but rather to entirely different mind-sets.

### *SCALE May Be Influencing How STEM Faculty and Academic Staff Approach Pedagogy*

Another effect of Math Masters on a few UW-Madison faculty is that their experiences with K–12 teachers have helped them recognize that all educators share certain challenges. In particular, some STEM faculty reported a newfound respect for the *science for all* movement, albeit with questions about how to best design and deliver the curriculum. They explained that a major impediment to IHE faculty acceptance of *science for all* as a mission is the pervasive value that a main role of Research I universities is to train and nurture "the best" students for future careers in academia or research. This perception has shaped the traditional pedagogical philosophy of the STEM disciplines, which holds that students will self-select into these majors by surviving demanding courses that predominantly rely on content-rich lectures.

***"SCALE has made me a better science educator, and those lessons will not disappear when SCALE is over." (CBE staff)***

Some respondents asserted that SCALE is helping IHE faculty become aware of and critique taken-for-granted beliefs and practices. They attribute this outcome to participation in Math Masters and the Science Immersion Units, which are designed not only to deliver content, but also to push the K–12 teachers to develop a deep understanding of the scientific concepts and appropriate pedagogy for their respective grade levels. This approach forces IHE professional development curriculum designers to consider how to engage all K–12 teachers in a session so that the content-based pedagogy can be experienced by each teacher, regardless of ability or prior knowledge of science. It also forces STEM faculty who actively participate in SCALE professional development sessions to learn inquiry-based pedagogy in order to model the techniques for K–12 teachers. One respondent admitted that it was difficult to learn the instructional techniques employed by SCALE in these sessions.

> So we were supposed to be modeling the pedagogy that they were to be teaching in their class. Modeling the first time around for me was something I had never done before. It was kind of mentally taxing. It was really hard. I had to work extremely hard the first time, even when [an MMSD leader] was running it. [It was hard] for me to do things

> right and learn and also be a model for something I'd never done before. It's completely insane if you think about it. (Engineering faculty)

This comment illustrates how difficult these methods are, and how foreign the concept of inquiry-based learning is for many STEM faculty. It is also important to note that similar efforts in pedagogical change are occurring in other venues at UW-Madison, such as the Center for Biology Education (CBE) and CIRTL. For example, one STEM expert on the CBE staff noted that "SCALE has made me a better science educator, and those lessons will not disappear when SCALE is over." One result of the overlapping activities of these reform efforts is the cumulative and ever-widening circles of influence these efforts have on individual faculty and staff.

### *Issues Related to Institutionalization*

Since the Title IIB funding for Math Masters expired in the fall of 2006, the question of institutional support has become imperative to address. The program will continue into the coming years with support from the UW-Madison Mathematics Department, which will provide stipends for participating faculty, and from MMSD, which will provide release time for its teachers. This reveals a significant aspect of the Math Masters theory of change: that the long-term success of the program, and the eventual impact on K–12 math education, require the institutionalization of program support and administration. Furthermore, the leaders of this program have a long-term vision that the Wisconsin Department of Public Instruction, and possibly the state legislature, will mandate that professional development programs such as Math Masters be required for K–12 teachers in Wisconsin. In addition, they are pursuing, as another spin-off of Math Masters, a Science Masters program. They plan to model this science program on Math Masters, and in July 2006, they submitted a proposal to the Wisconsin Department of Public Instruction to initiate the program.

In addition, the Math Masters program's strategy for change regarding institutional partnerships is to encourage the collaborative design and implementation of the workshops. They believe that new partnerships based on shared goals will create new opportunities for future funding, give rise to other new partnerships, and leverage resources. The program leaders' strategy for influencing STEM undergraduate education is to recruit STEM faculty to co-design and facilitate professional development sessions with MMSD math educators and teachers. Through this process, and the active modeling of this new pedagogy, they hope that the STEM faculty participants will gain a new understanding of active learning strategies. In this regard, we note that some respondents questioned this core strategy of using STEM faculty in Math Masters; they suggested that math educators, who are conversant with pedagogical issues, might be more effective.

## Pre-Service Curricular Reform

### *General Overview*

The UW-Madison School of Education recently launched the Teacher Education as an All University Responsibility Project. College leaders initiated this project in response to perceived problems with the elementary education program, particularly its curricular requirements, and to address the detrimental effects of little or no interdepartmental collaboration. As part of this effort, an associate dean formed a University Teacher Education Council (http://www.education.wisc.edu/teacherprep/allUnivRes.asp). This council, composed of representatives from the School of Education, the College of Letters and Science, and local public schools, is responsible for discussing issues related to teacher education on campus. Activities of the Teacher Education as an All University Responsibility Project relevant to science and math education include:

- The Middle School Math Pre-Service Committee, a joint math and math education committee charged with discussing math content preparation of elementary, middle school, and special education teachers; and

- The Middle School Science Pre-Service Committee, a new committee to review middle school science requirements, led in part by SCALE personnel.

SCALE personnel participate in these efforts and "bring the SCALE perspective" to bear on their activities.

The Middle School Math Pre-Service Committee is discussing the possibility of developing a middle school math certificate program at UW-Madison. One goal of this committee is that their work eventually influence the state Department of Public Instruction to adopt a new requirement for middle school math certification. At this time, aspiring middle school teachers can be licensed by meeting state requirements in the Early Childhood Through Middle Childhood Regular Education category. This license, which only requires the three-course math sequence designed for teachers (Math 130, 131, 132), is considered by many respondents to be insufficient for elementary teachers, let alone for middle school math teachers. While there is a committee devoted to this course sequence, the Math 13X Committee, the activities of the Middle School Math Pre-Service Committee are of primary interest for this case study research because faculty and students on this committee spent the summer of 2006 researching middle school math course requirements from across the country, in order to make an informed proposal for the new UW-Madison sequence. The chair of the Mathematics Department supports this effort and is invested in involving MMSD staff, including the math coordinator and three teachers, in this initiative.

The Middle School Science Pre-Service Committee is focused on revising the science requirements for future middle school science teachers. Current requirements for middle school teacher candidates are the same as those for elementary candidates and thus are considered by many respondents to constitute insufficient content preparation for middle school. In June 2006, several faculty from the School of Education and different STEM departments attended an introductory meeting and discussed various aspects of this effort. Note that in the following section, we discuss key aspects of the organizational cultures of UW-Madison that pertain to promoting interdepartmental collaborations of this type.

## *Assessment of Program Goals and Objectives*

The Middle School Math Pre-Service Committee is attempting to redesign the pre-service middle school math sequence and hopes to engage other UW campuses and eventually the Wisconsin Department of Public Instruction to eventually change and strengthen the credential requirements for middle school mathematics teachers.

The Middle School Science Pre-Service Committee is still in its early stages of development, and while there are no clearly articulated goals or objectives for the committee, it appears that the committee hopes to review and revise the credential requirements for middle school science teachers at UW-Madison. A required core, multidisciplinary sequence is a possible outcome of this committee's work.

## *Initial Outcomes*

### *SCALE Is Contributing to an Active Middle School Math Pre-Service Committee*

In December 2005, the Middle School Math Pre-Service Committee began meeting, due in part to leadership from the assistant dean from the School of Education. One reason this dean took action was that the Mathematics Department had raised the issue that elementary and secondary teachers have the same content preparation, which seemed problematic. SCALE personnel were instrumental in organizing and providing leadership for this committee, and several committee members are active in the Math Masters program. Respondents from both the School of Education and the Mathematics Department reported that the committee is making progress. It is focused on creating different pathways for elementary and middle school teachers, revisiting the textbooks and content requirements for the sequence, and considering ways to better integrate the courses taught by the Mathematics Department with the math methods course taught in the School of Education.

However, one respondent noted that the prospects for changes to the education degree are minimal in the near term, since adding, changing, or removing courses at UW-Madison can be a very political and challenging exercise. Furthermore, while the committee may effect some change in course requirements, some respondents questioned the ultimate efficacy of the committee's work, since student learning outcomes from the 13X courses depend as much on the pedagogical approaches and skill of individual members of the Mathematics Department as on the curriculum. One respondent who expressed this view said,

> I really doubt it [will make a difference] because ultimately those classes are housed in the Math Department and, for the most part, it seems to me that the people teaching them are not interested in or knowledgeable or sympathetic to reform efforts in math education. So no matter how much our committee goes back and forth talking about things and changing things, I don't see how it's going to make any difference when it actually gets taught. (School of Education faculty)

### *SCALE Is Facilitating an Interdepartmental Revision of the Math 13X Courses*

In the summer of 2006, SCALE funded an effort on the part of the Middle School Math Pre-Service Committee to research other IHE math pre-service courses and innovative curricula. In addition, one faculty member from the Mathematics Department, one faculty member from the Curriculum and Instruction Department, and graduate students from their respective programs are assessing each course in the Math 13X sequence and providing recommendations for changes and updates.

### *SCALE Is Organizing a New Middle School Science Curriculum Committee*

In the summer of 2006, the SCALE PI began gauging interest among various STEM faculty, administrators, and K–12 partners in an attempt to develop a new course sequence for pre-service middle school science teachers at UW-Madison. It is possible that the School of Education, as part of its Teacher Education as an All University Responsibility Project, will authorize this new committee and charge it with identifying solutions to this problem. At the initial meeting, 13 faculty and administrators from various STEM departments, the School of Education, and SCALE convened to discuss the need for such a committee. Most agreed that the science content knowledge of both K–12 teachers and students should improve and that a committee should be formed. Initial suggestions included new interdisciplinary courses, a dual focus on improved content and pedagogy, and an investigation of numerous resources available for interdisciplinary science education at UW-Madison. The progress of this committee will be closely monitored for Phase 2 of this case study.

## *Issues Related to Institutionalization*

The strategy regarding curricular change for the Teacher Education as an All University Responsibility Project appears to focus on engaging faculty who are in decision-making positions and who are committed to reforming the pre-service program at UW-Madison. Through interdepartmental committees that are sponsored by the School of Education, these efforts enjoy administrative support within the institution, yet this support alone is not sufficient to guarantee the adoption of recommended changes. Some respondents noted that finding and engaging committed faculty over the long term is equally important. In answer to a question about how many faculty are required to effect change in these areas, a respondent answered:

> I mean, there’s some people who [I] have been trying to get involved in these committees; they say they’ll be involved and they never come. I mean, just get rid of those people. There are enough people who respond positively that my feeling is that all it takes is going out and bringing people in. (School of Education faculty)

This comment illustrates the strategy of simply focusing on faculty predisposed to change and ignoring those considered intractable. The next step in actually instituting the recommended changes to the math and science pre-service program, or institutionalizing these change efforts, will be actively studied in Phase 2 of this research. At this point, the nature of the barriers to and opportunities for institutionalizing these curricular reform efforts is unclear.

## Science Immersion Unit Design

### *General Overview*

One of SCALE's major activities is the development of Science Immersion Units for use in professional development for K–12 math and science teachers. An immersion unit is a carefully selected and designed learning opportunity in which students engage in the scientific inquiry process over an extended period of time (4 weeks), focusing intensely on a particular concept or big idea in the content area (Lauffer, 2004). Each immersion unit provides a coherent series of lessons designed to guide students in developing deep conceptual understanding that is aligned with key science concepts and the essential features of classroom inquiry specified in the national standards and the state standards of the district for which each is designed. In each unit, students learn academic content by working like scientists: making observations, asking questions, doing further investigations to explore and explain natural phenomena, and communicating results based on evidence.

At UW-Madison, the IHE faculty involved in the design of the Science Immersion Units are staff at the Center for Biology Education, an outreach specialist in a STEM discipline, and one STEM faculty member. One aspect of the SCALE immersion unit strategy is to leverage existing resources by identifying and utilizing *immersion resources*—that is, STEM research or education programs already developed at IHEs. SCALE staff redesign these resources, write and test the units, and train STEM and K–12 personnel to facilitate week-long professional development seminars for K–12 teacher leaders and teachers. By training teams of immersion unit facilitators, SCALE staff hope to develop local capacity for professional development by "training the trainers." SCALE leaders also expect that—as a result of exposure, while working on immersion units, to the process of teaching through inquiry—STEM faculty will change their own approach to undergraduate teaching. SCALE leaders also hope that the immersion unit collaborations will encourage future IHE/K–12 collaborations.

To date, SCALE staff at the Wisconsin Center for Education Research and STEM and education faculty have collaborated on units for third grade (structures of life), fourth grade (electricity and magnetism), fifth grade (climate and ecosystems), sixth grade (diversity of life), and seventh grade (exploring earth's landforms). In Section E, we discuss key aspects of the organizational cultures of UW-Madison that pertain to promoting this type of IHE/K–12 collaboration.

### *Assessment of Program Goals and Objectives*

The goals for the Science Immersion Units focus entirely on designing and facilitating a learning process for participating K–12 teachers that encourages inquiry-based learning. While there are no explicit goals for IHE participation, respondents inferred (as noted above) that one goal is to expose IHE faculty to new approaches to pedagogy and collaboration with K–12 in the hopes that they will act on these approaches back in their home institutions. This also is a goal of the Math Masters program.

### *Initial Outcomes*

As previously mentioned, since the Math Masters program and the Science Immersion Units goals regarding IHE involvement are so similar, many of the findings for one program also apply to the other. Some of the initial outcomes for the Science Immersion Units are addressed in the earlier section on Math Masters.

Here, we address SCALE's influence on the ways in which IHEs approach their interactions with K–12. One IHE respondent, a former staff member at the Center for Biology Education, observed a significant change in his own approach to working with K–12 educators:

> Before, we were pretty much this spray-and-pray operation. You go out and you do a workshop and you let it go. You put it out there and you let teachers do what they want to do. We really only had the patience to deal with the top 1–2% of teachers. These are the people who inspired us. They were already scientists in the classroom doing fun things. We didn't have to muddle through the larger piece. When SCALE began, we were looking at 100% of students, when in reality the tipping point is getting maybe 60–80% of the teachers on board, and that's enough of a tipping point to make a difference in a large district. (CBE staff)

STEM faculty at UW-Madison and elsewhere corroborated that they experienced a similar outcome. Through their participation in SCALE, they developed a better understanding of the diverse learning styles and abilities of K–12 students. While this realization itself may not translate into any immediate behavior changes, respondents noted that it brought to life the difficulties K–12 teachers face in improving math and science student outcomes, some of which STEM faculty also face with their undergraduate students.

### *Issues Related to Institutionalization*

Respondents indicated that a primary goal that SCALE leaders hold for the Science Immersion Units is to help K–12 curriculum designers develop the internal capacity to continue these efforts after the SCALE grant expires. The design teams involving UW-Madison included SCALE staff, personnel from MMSD, the Center for Biology Education at UW-Madison, and one STEM faculty member. Current efforts focus on developing the relationship with MMSD personnel and creating high-quality immersion units for the coming year. The barriers and opportunities related to institutionalizing the Science Immersion Units at UW-Madison will be investigated in greater detail in Phase 2 of this research.

# D. FACTORS THAT IMPEDE OR SUPPORT SCALE ACTIVITIES AT UW-MADISON

## Overview

Various factors exert influence on UW-Madison and SCALE operations and profoundly shape the form and impact of their respective activities. These factors include the political and economic context of funding for UW-Madison, trends and policies affecting higher education overall and its various academic disciplines, and the status of local K–12 districts, to name but a few. While it is not within the purview of the IHE case studies to assess all the societal, institutional, and cultural contexts that affect UW-Madison and SCALE, we bring attention to certain aspects of these contexts that have a direct and observable impact. Accordingly, this section briefly describes the factors that have impeded or supported SCALE activities at UW-Madison, based on the experience and opinions of interview respondents, document analysis, and observations. These factors are important to consider in assessing the outcomes of the three SCALE activities described above and in understanding why these activities had any noticeable effect on the institutional policies or practices of UW-Madison.

## Factors Influencing All SCALE Efforts

The following issues and topics are factors that respondents claimed influence or pervade the entire institution of UW-Madison.

### *Persistence of the "Transmission-of-Content" Approach to Instruction*

Some respondents expressed the view that faculty members' approach to pedagogy is often informed and influenced by their own pedagogical training, or lack thereof, and in many cases replicates the approach of their mentors. In many cases, respondents observed that the traditional teaching model used in IHEs is *transmission of content*, in which the instructor conveys a body of information, usually through a lecture, with the expectation that the students will study and absorb the information. We note that this model is supported by the dominant ethos of the university as a top-tier research institution, which focuses on training the best in the field. Evidence for this observation is based on various respondent comments. For example, one respondent noted that what students expect to get from UW-Madison is not the best teaching methodology, but rather the opportunity to be around "great researchers who have some kind of aura that you try and soak in." As another example, one respondent asserted that because some faculty assume that instruction is primarily about content transmission, they assume that an accomplished researcher automatically is an effective teacher. This position, which some respondents dubbed a *paradigm of teaching*, is prevalent throughout the university. We note that one goal of reform efforts such as SCALE is to encourage more faculty to become critically aware of this paradigm and shift to a *paradigm of learning* (Barr & Tagg 1995).

It is important to note that most respondents stated that the majority of their colleagues are committed to teaching; the few faculty who are not are either more focused on research or have simply lost interest in improving their lectures or teaching approach. Indeed, one respondent noted that the transmission-of-content approach and a serious commitment to instruction are not mutually exclusive. This respondent observed that some mathematicians consider rote learning appropriate for lower level mathematics, including K–12 and some undergraduate mathematics, but that "they do not want their students in calculus classes doing something by rote, they want understanding." Thus, some faculty approach teaching very seriously but reserve their serious efforts more for graduate students than undergraduates, and more for majors than non-majors. In this regard, respondents noted that it is not uncommon for faculty and graduate students to view the teaching of large introductory-level courses as a relatively uninteresting chore.

Several respondents also noted that there is a conflict between the emerging *science for all* movement and the traditional view that higher education, particularly in the STEM disciplines, should focus on a select, especially able, few. These individuals believe that this conflict will not be resolved by convincing a recalcitrant, elitist professoriate, but rather will entail a complete shift from a paradigm of teaching to a paradigm of learning.

### ***Denigration of Teaching in Favor of Research***

The previously mentioned lack of interest among STEM faculty in teaching innovations, reforms, or pedagogical improvement was cited by several respondents as a major roadblock for SCALE. This lack of interest does not necessarily mean STEM faculty are not good instructors or committed to their teaching. Instead, respondents stated that a combination of factors—including faculty commitment to research, the persistence of the transmission-of-content approach to teaching, and an aversion in the "hard" sciences to the "soft" sciences—contribute to a widespread sentiment that teaching is simple, secondary, and in no need of further attention or improvement. A practical corollary of this dynamic is the departmental practice of separating teaching and research activities. For example, one STEM department hired a faculty member specifically to focus on outreach and education—in effect, to not be a researcher. This distinction is perceived by some SCALE participants as inimical to teaching enhancement efforts. In such an environment, where a focus on pedagogy and teaching enhancement is not encouraged, one respondent reported that his STEM department was not "pro-education" and thus his SCALE activities remained "under the radar." In this atmosphere, faculty may have little incentive or desire to change or improve their instructional methods. Further, one respondent from the Mathematics Department, who ascribed a lack of interest in teaching to the "publish or perish" mentality of junior faculty, described his experience presenting a workshop on the use of technology in mathematics instruction by saying, "What worries me most is the younger guys, the 30-year-olds, who said 'That was interesting, but if I did that I would have to change my exams.'"

Some respondents noted that some of their colleagues express a general lack of awareness of and interest in non-majors as well, and an attitude that the non-majors are "not my students." We note that this attitude works against efforts by SCALE and other initiatives to help STEM faculty realize that their approach to teaching, and the quality of their teaching, influence the next generation of K–12 math and science teachers.

### *Structure of Undergraduate Courses*

Many introductory undergraduate courses in the STEM disciplines are taught in large lecture halls (with as many as 300 students) by a rotating staff of faculty, including tenure-track professors, adjunct faculty, and graduate students. These lower division courses are a major source of the criticism leveled at higher education, since the structure of the courses thwarts efforts to use teaching methods designed to engage students and thus affords students little opportunity to interact with their instructors or fellow students. Since many pre-service teacher candidates' only exposure to the STEM disciplines is in these introductory courses, the quality of the teaching and the pedagogy that is modeled was of particular concern to several respondents. Another concern voiced by respondents was that the teaching rotation system, which sometimes assigns faculty who view lower division courses as "an obligation and a chore," does not promote the iterative improvement of a particular course.

### *Tenure and Promotion Policies That Discourage Teaching Innovations*

As noted when reviewing UW-Madison policies, research and teaching activity are the primary considerations for tenure, with professional service playing a minor role. In practice, respondents reported that recruitment and promotion committees may emphasize research over teaching, noting that this is not surprising at a Research I institution. One respondent was actively discouraged from focusing on improving her teaching, due to the risk that her student evaluations—a key component of the review process—would be poor during the period when she was making changes.

> People have told me they've experimented with different teaching styles and they get hammered on their evaluations. One of the assistant professors said to me, "Oh no, you do not [experiment with your teaching] until you have tenure. Just get high scores. Do not worry. You know, no surprises, give out a syllabus, follow it to the T, be predictable, do not challenge or tax your students and you'll get good evaluations." And I'm thinking, "Do not challenge or tax your students? That's really good advice." (Math faculty)

Respondents repeatedly emphasized the importance of one's standing in the field and tenure status. One respondent referred to eminent physicist Carl Weiman as an illustration of the importance of achieving the safety of tenure and high status before becoming involved in non-research activities. In short, the increased pressure on junior faculty to get positive teaching evaluations and focus on their research serves to inhibit their efforts to improve teaching that involves changing the traditional paradigm.

### *Retirement and New Generations of Faculty*

Some respondents noted a generational difference in faculty willingness to change teaching styles, while others denied that this was a phenomenon. Respondents did observe that some new, incoming faculty were particularly interested in learning how to teach and presented a real opportunity for change. We observe that this interest may signal that a paradigm shift is likely as older, more traditional faculty retire.

### *General Faculty Disengagement from K–12*

There is a well-documented perception in the U.S. that people in K–12 education feel patronized by faculty from higher education (Gilroy 2003; Davis, Feldman, Irwin, & Pedevillano, 2003; Haycock, 1998). This tendency is less pronounced among education faculty, since many of them are former high school teachers and education is their subject matter and research topic. This difference between education and other disciplines within higher education was evident in our interview data in that several respondents noted that the tendency of STEM faculty to treat K–12 teachers with disrespect and arrogance significantly inhibits collaborative efforts such as Math Masters and the Science Immersion Units. For example, MMSD staff reported instances in which STEM faculty, while presenting at professional development sessions, insisted that complicated theorems were the best way to solve problems, when these approaches clearly were not appropriate. This said, one STEM faculty member noted that the K–12 distaste for IHEs is not limited to STEM faculty, but also extends to education faculty at times. Also of note, despite the reported dislike of IHE faculty, respondents observed that K–12 teachers hold the faculty in high regard and felt that their participation in Math Masters lent the program a certain legitimacy.

Regarding the lack of interest in K–12 issues among many IHE faculty, one respondent stated that since UW-Madison is a research university, it makes sense that people focus on research and not K–12. He observed that the education faculty should work on education issues, just as physicists focus on physics and chemists focus on chemistry. In another case, a STEM faculty member was clear in stating that very few people in his department cared about K–12 education "in any overt way," and those who did worked "behind the scenes and that's the way it works." This attitude is also evident in the value systems of STEM faculty and in policies that base promotions and salary increases primarily on research accomplishments, and only a little, if at all, on accomplishments in service or teaching. In fact, some respondents noted that involvement with K–12 and/or teaching reform efforts can serve to alienate faculty members and make them "suspect" in the eyes of their colleagues.

The disengagement of IHE faculty from K–12 also is expressed in a frequent misalignment of needs and strategies. For example, many of the minority of faculty who participate in outreach to K–12 teachers do so by seeking to "reach the brightest," rather than trying to meet the needs of all. As another example, one respondent described a "love-hate" relationship with the Wisconsin standards, explaining that some colleagues became involved with MMSD issues in order to "correct" the district's perspectives on education. One of the stated needs of K–12 districts is that IHE faculty realize that K–12 is a system with its own constraints, such as compliance with state and national standards. As we noted above, MMSD personnel find that the intermittent involvement of IHE faculty who dabble in K–12 for the duration of a grant is not helpful. K–12 districts need a more consistent presence and engagement. We have some evidence that, while some of this misalignment between K–12 needs and IHE efforts to contribute can be attributed to an arrogant attitude, in many cases the problem is a simple lack of understanding of K–12 realities. Although some respondents were conversant with K–12 issues, several admitted that they knew little about the needs of K–12 educators other than what they read in the news or heard about from their children and other parents.

### *Challenges with Workloads*

One of the biggest barriers to IHE and K–12 collaboration noted by STEM faculty is the limiting factor of time. The STEM workload simply does not allow for activities that, in their view, lie outside the core activities of research and teaching. This is a particularly important issue for junior faculty, who are under pressure to “publish or perish.” However, some faculty who receive NSF funds and have chosen to work with K–12 in order to satisfy NSF’s broader impacts criterion (Criterion 2; see next section) expressed strong resistance to what they perceive as having to undertake work that is not in their job description. One respondent stated that there is outright hostility to the concept in some venues, particularly among the “hard-core” researchers. Another respondent noted that some STEM faculty “just pay lip service” to outreach and rarely carry out the broader impacts activities promised in their grant proposals.

### *NSF Broader Impacts Requirement*

As noted above, NSF’s Criterion 2 is a driving force in engaging STEM faculty with K–12 issues. While some faculty may pay “lip service” to the broader impacts of their research, others are genuinely committed to the effort. In any case, understanding how this policy plays out in reality is a significant factor contributing to evolving IHE/K–12 partnerships.

### *Self-Imposed Faculty Expertise Criterion That Impairs Willingness to Engage K–12*

Some STEM faculty noted that they were less willing to experiment with unfamiliar areas of teaching or get involved with K–12 issues since they had little or no training in education. One respondent clearly stated that he was very hesitant to participate in any K–12 activity, including professional development, since he had no training in education or pedagogy. While the validity of this hesitancy is difficult to assess, given the respondent’s stated preference for research and lack of time to conduct his basic job responsibilities, it corroborates other findings about this self-imposed expertise criterion that academics face (Rouse & Sapiro, 2005).

## Factors Specific to Math Masters

The Math Masters project draws upon UW-Madison faculty for its primary instructors in the professional development workshops and thus is influenced by certain aspects of the organizational cultures of the university. An immediate example is the influence of the controversy over constructivist pedagogical strategies, also known as the Math Wars, about which many UW-Madison mathematics faculty have very strong opinions. Certain faculty are particularly concerned about constructivist curriculum. They believe that, especially in the early years of the Math Wars, these curricula were developed too quickly, decisions were made by math educators instead of research mathematicians, and adoption involved questionable financial incentives for K–12 school districts.

It is our view that these positions on math education serve not as a passive backdrop to the Math Masters program, but as an active force that has shaped the attitudes, values, and practices of many mathematics faculty. Some respondents described the current climate in the Mathematics Department as tense and strongly divided, yet not as bitter as in recent years. Interestingly, a reason given for this recent warming of relations was the commonly shared opinion that K–12 math teachers' and students' mathematics ability needs serious attention and improvement. Another shared concern among several math faculty is the state of middle school certification in Wisconsin, which was described as still in the "stone age," since there is no structure or coherent set of course requirements for future middle school math teachers. These shared beliefs form the foundation for some of the collaborative efforts described above.

## Factors Specific to Pre-Service Curricular Reform and Science Immersion

### *Distrust Between STEM and Education Faculty*

Attempts to engage STEM and education faculty in joint efforts to improve the curriculum and pedagogy for pre-service teachers are hampered by a historical and persistent distrust between these groups. One aspect of this distrust is the perception by many STEM faculty that education research is substandard. As one respondent noted, most STEM faculty think that education is a good thing but have a negative feeling about researching how people learn. This perception is expressed in both subtle and not so subtle ways, but it is a very real and acknowledged perception linked to the higher status of "pure" research over "applied," and of the "hard" sciences over the "soft" ones. In some cases, this divide has created a climate of hostility that makes collaboration problematic. This hostility is illustrated by a story one respondent told:

> He was in our faculty, and at a department meeting he said, "I will never trust anything that comes from an ed school." But on the other hand, what they don't realize, I've been at meetings over on the other side of things, and I can exactly remember one person who I could name who said, yelling out, "I'll never trust anything from a math department!" (Math faculty)

Another STEM faculty member clearly admitted holding the view that educators are involved in altruistic, and thus inferior, research and other activities. Other respondents noted that a commonly held perspective is that most people in the School of Education are "practitioners" and "do-gooders" who try to make the world a better place through applied work. Another common perspective noted by respondents is that educators pay insufficient attention to content mastery. A STEM faculty member felt that content-based pedagogy was over-designed by "methodologists" and noted his displeasure with curriculum developed through an NSF grant by education specialists. He found it unwieldy and believed that it "over-complicated" the content.

In contrast, another respondent noted that people tend to turn to content specialists (i.e., scientists) on issues in math and science education and explained that this tendency is based on a societal and academic bias towards pure, scientific research. Some education faculty dislike this bias and noted that it is evident in the NSF math and science partnerships, including SCALE, where relatively few educators are involved in either the planning or the implementation of the project. In this regard, one respondent questioned SCALE leaders' decision not to substantively engage School of Education faculty in SCALE operations, as it is math and science education faculty who have expertise in pedagogical issues. Thus, the distrust is a two-way street, with some educators disliking what they view as STEM faculty dabbling in education.

### *Willingness to Combine Strengths, Despite Different Ideas About Teacher Training*

At UW-Madison, divisions and disagreements between the STEM faculty (who are identified as "content specialists") and education faculty (who are identified as "methodology specialists") primarily are evident in regard to pre-service teacher education. In some respects, however, these distinctions are not viewed negatively. For example, there appears to be agreement among both STEM and education faculty respondents that the content preparation of pre-service math and science teachers needs to improve. While significant differences of opinion remain over curriculum content and methods of delivery, there is consensus that all parties have unique strengths and talents that should inform the process of improving pre-service training.

> You can't just have content experts designing teacher preparation, ignoring everything we know about teacher learning and so on. And you can't have people who don't know the content knowledge deeply making those decisions either. So you really need the engagement, a broader engagement in the act of teacher education. (School of Education administrator)

Echoing parts of this opinion, some STEM faculty nonetheless expressed discomfort that so few "professional" (STEM) researchers are consulted in the development of K–12 curriculum. Some STEM faculty have responded to this perceived problem by advocating an increase in the number of "content" courses required for pre-service teachers, and a decrease in the number of methods courses. However, the selection of the appropriate content for pre-service teachers is not a simple matter, as evidenced by these observations from an MMSD instructor:

> For determining the content teachers need to know, the best source is not our own past experiences and beliefs but rather the current national, state, and even local mathematics standards. The common practice of looking at the table of contents of any text materials under consideration for a course without precise knowledge of what mathematics teachers need to know is not sufficient for this purpose. As I worked through the content in the [Math 13X course notes] this semester, I was struck by what a large amount of the content was irrelevant to the work of K–8 teachers, and how much more in-depth the discussions could have been about the essential content if the extraneous material were eliminated. Since the 130 course is the only course on number operations, the core of the mathematics taught in elementary grades, it troubles me that time is taken for exploration

> of irrelevant, albeit interesting, mathematics at the expense of time spent on building understanding of essential mathematics. (MMSD personnel)

Furthermore, some respondents observed that a reliance on the “core” content courses as currently taught in STEM departments to ensure the preparation of math and science teachers is a mistake. These respondents observed that the research indicates that accumulating courses in a major does not automatically make someone a good teacher, and that the problem is that there is no “connection between the content preparation and the pedagogy.” However, at least in mathematics, it is precisely this approach that is a major topic of debate. Many school districts, including MMSD, have adopted a math curriculum, Connected Math, that emphasizes a constructivist approach to learning. Despite disagreements over the merits of the curriculum, there is a growing agreement among STEM and education faculty that because it is so demanding, problems arise if the instructors do not understand the content. This observation highlights some of the challenges facing interdepartmental collaboration on pre-service issues. The current constructivist curriculum requires a solid background in both content and pedagogy and raises questions about the deleterious impacts of the stark separation of responsibilities between STEM and education faculty that currently prevails at UW-Madison.

### *Lack of STEM Faculty Awareness About Pre-Service Candidates*

Since pre-service students are in courses with a variety of other majors and are rarely identified as pre-service teachers, instructors are often not attuned to the unique needs of these students. At one extreme, a science faculty member was not even aware that future teachers were trained at UW-Madison. More commonly, STEM faculty are not aware that pre-service students are in their courses since they are scattered throughout large, introductory lectures. A respondent from the School of Education stated that the delegation of pre-service teacher content instruction to STEM departments is “just the way things are” and expressed the view that the institutional context that supports this arrangement is relatively intractable. This said, the context for mathematics is different from that for science because there has long been a sequence of courses (the 13X sequence) that is specifically for pre-service teachers. One education faculty member noted that the math faculty must be aware that their students are future teachers, although this probably does not affect their pedagogy.

However, it is important to note that some STEM faculty were not only aware of pre-service activities on campus, but actively sought to make their undergraduate courses more focused on pedagogical concerns by creating special discussion sections solely for students interested in science education. While one respondent voiced a concern that these sections could be considered less rigorous or even distasteful to most students, other respondents were actively seeking ways to create more pedagogy-based discussion sections. However, these respondents expressed concern that there is no way to guarantee that a properly trained or sympathetic faculty member would consistently oversee the section.

### *Divide Between the School of Education and the College of Letters and Science*

Several respondents referred to the traditional divisions between the “hard” and “soft” sciences and “pure” and “applied” research as pervasive at UW-Madison. The institutional context of UW-Madison, where research activities in the STEM disciplines are viewed as a priority to maintain prestige and funding levels, serves to reinforce a predisposition to rank “pure” research activities over teaching and even research on teaching. While this in itself does not naturally translate into a denigration of education, the respondents felt that the research orientation exacerbates existing stereotypes and divisions between the School of Education and the College of Letters and Science.

### *Perception That the Responsibility for Teacher Education Is with the School of Education*

The longstanding perception that teacher education is the responsibility of the School of Education is based in the creation of separate “normal” schools for teachers in the late 19th century (Labaree, 2004). As teacher education became integrated into state universities and colleges, the practical and conceptual separation continued, and according to several respondents, it persists to this day at UW-Madison.

### *IHE Departments Operating as Isolated “Silos” with Regard to Pre-Service Teachers*

Academic departments tend to operate as isolated “silos” within the institution, with interdisciplinary collaboration largely taking place in extra-departmental research centers. Indeed, UW-Madison is known for its strong interdisciplinary research centers. However, some respondents argued that because of the university’s size, and the amount of research under way in departments and extra-departmental research centers, faculty have little time or incentive to participate in department-based collaborations that focus on the needs of pre-service teachers. When interdepartmental collaborations are required, the additional intellectual and practical work may be more than some faculty desire.

### *K–12 Hiring Practices*

A problem observed by respondents is that K–12 districts often prefer teachers without a specialization in math or science, so that they can place teachers wherever they are needed. This preference deeply affects hiring practices and is a structural concern voiced by several respondents in both interviews and meetings about revising the pre-service sequence for elementary education majors.

### *Disagreement About Special Sections for Pre-Service Teachers*

One strategy employed at UW-Madison to ensure that the unique needs of pre-service teacher candidates are met in undergraduate STEM courses is to create discussion sections specifically focused on pedagogical concerns. An introductory chemistry section was designed for this purpose and taught by a graduate student whose primary research interest was science education. Another respondent spoke about a university-wide initiative to create pedagogy-focused sections in each of the colleges on campus. In contrast, other respondents felt that the current structure and political and economic climate at UW-Madison are not amenable to such efforts.

### *Diverse and Personal Faculty Motivations for Becoming Engaged in K–12 Activities*

Respondents identified a variety of personal, political, and practical reasons for becoming involved in K–12 activities. Many faculty, particularly in the School of Education, were former high school teachers and were predisposed to involvement in pre- and in-service activities. For STEM faculty, the reasons are less professional and more personal. Several noted that having children in the school system was the primary factor leading to their engagement with K–12 issues.

> I certainly was not very interested coming out of graduate school. I think it's fair to say that the main source of interest for professional mathematicians tends to be when they have children in the public schools. Then suddenly they get very interested. (Math faculty)

Another STEM faculty member became interested in participating in a SCALE professional development program in order to get a firsthand glimpse at the controversial constructivist curriculum that is debated in his department. Thus, another less obvious variable that may attract faculty is the personal and intellectual stimulation that may result from the activity.

### *Widely Recognized Need for Professional Development*

While most respondents were aware that their undergraduate and K–12 students had gaps in their science and math comprehension, several were surprised at the lack of comfort and ability among K–12 instructors. These respondents learned this firsthand through participation in K–12 outreach or professional development sessions.

> I had no clue how little math the middle school teachers actually . . . I mean I had some hint, but I was actually surprised at how little math they had and how uncomfortable and math phobic a lot of them were. (Math faculty)

## E. ORGANIZATIONAL CULTURE AT UW-MADISON

### Overview

Interview respondents frequently used the concept of *organizational culture* when explaining how elements of the UW-Madison structural and political context either precluded or facilitated change. For example, some respondents attributed the dominance of the transmission-of-content approach to instruction in STEM departments to the culture of the discipline and their departments. They invoked this term to explain diverse and important phenomena—multiple responsibilities (research, teaching, service) and multiple professional identities (departmental, disciplinary, personal), institutional policies, and shared and individual values and practices. However, when pressed for a definition of the term, few could specify precisely what constitutes culture or how it changes over time.

To better understand this theme of organizational culture that emerged from our interview data, we conducted a literature review in the early stage of analysis. The literature on organizational culture spans several fields and has been employed in a higher education context in several instances. This literature (briefly reviewed below) tends to use the culture concept to refer to convergence, across differences, to normative consensus (e.g., Berquist, 1992; Bate, 1997; Kezar & Eckel, 2002). This usage, however, runs counter to the way the concept was used by our interviewees. Furthermore, a critique of the literature on organizational climate, which is closely related to the organizational culture construct, is pertinent to this case study. Glick (1985, p. 602) asserted that applying the same theoretical construct to different organizational units results in a "conceptual morass." The *unit of theory* approach that plagued the fields of organizational culture and climate in the 1980s continues to be debated even today (Ashkanasy, Wilderom, & Peterson, 2000).

Given the important explanatory role that organizational culture plays in our interview data, we venture that it will be useful to consider reform efforts like SCALE in terms of this concept. To that end, we present a definition of organizational culture and a preliminary assessment—drawn from the interviews, document analysis, observations, and researcher analysis—of the organizational culture of UW-Madison and its effects on SCALE activities. Due to the limitations of our small interview sample, this assessment cannot be generalized to all of UW-Madison or even to individual departments. However, it provides preliminary findings on key factors that inhibit or enhance SCALE's strategies for improving math and science education.

## What Is Organizational Culture?

Many studies of IHEs emphasize the importance of understanding the structure of the institution and the ways in which departments and individuals "make sense" of the dynamic between institutional forces and academic autonomy (Birnbaum, 1988). In our view, this last point is a weak area in the literature: attempts to develop "cultural" typologies of IHEs, IHE departments, and even individual faculty members do not adequately explain the nature of this dynamic, particularly for individual practice within an academic department. Speaking generally, the IHE literature does not adequately define or operationalize the oft-used concept of organizational culture. While some higher education researchers stand out for their more careful use of the concept (Kuh & Whitt, 1988), in our view they do not go far enough in defining and examining its meaning and use. Rather, like our respondents, most higher education researchers invoke the term *culture*—without actually defining it—to explain any complex of behavioral and practical routines within an organizational unit. Moreover, when invoking this term, they do not adequately explore variability within organizational units or examine how the policies and practices of particular units, and the units in which they are nested, affect the diverse ways in which individuals act, and vice versa. This point is particularly important in IHEs, where the notion of academic autonomy reinforces the individual's sense of separation from an institutional context.

For the most part, published works that study and prescribe processes of change in higher education give much attention to either the individual faculty member or the institution as a whole, and largely ignore activity systems and communities of practice on intermediate levels. In this case study, the intermediate organizational level is epitomized by the academic department. An exception to this generalization is Trowler and Cooper (2002), who view this "meso" level as the central locus from which to approach change in teaching and learning. In light of the importance our respondents give to organizational culture, we attempt to build on Trowler and Cooper's work. In particular, we propose to specify how organizational structures and policies and individual agency interact at different organizational levels of the institution, in order to more adequately understand the meaning of organizational culture within IHEs. Our hope is that this analytical process also will provide both reformers (such as SCALE leaders) and policy makers a useful strategy for understanding and acting on the complexity of policy and practice that operates at multiple levels at UW-Madison and other IHEs.

## A Framework for Analyzing Organizational Culture

For this preliminary analysis of factors that impede and support the strategies the SCALE project uses to achieve its goals at UW-Madison, we employ the following definition of organizational culture in higher education:

> Culture is the complex set of processes—that is, observable and self-reported "patterns of norms, values, practices, beliefs and assumptions that guide the behavior of individuals and groups in an institute of higher education and provide a frame of reference within which to interpret the meaning of events and actions on and off campus" (Kuh & Whitt, 1988)—and artifacts—that is, "human-made, designed objects of cultural significance, which, upon investigation, can provide insight into the nature of practice or meaning-making for a group of people" (Carter Ching, Levin, & Parisi, 2003)—that operate within nested structural levels of the institution.

To analyze cultural artifacts, we read official UW-Madison documents, reports, and written policies and observed how respondents used these artifacts to explain how different organizational units operate. To analyze cultural processes, we identified the meanings and values that individuals and groups ascribe to fleeting situations at different levels of the institution. For this preliminary stage of the research, we identified key artifacts and processes most pertinent to SCALE, and we intend to monitor any changes over the coming year. We will investigate the causes of any changes observed or reported and attempt to assess if and how SCALE was involved in these changes.

### *Main Levels of the Organizational Culture*

Based on an analysis of the interviews and a review of the literature on organizational culture and change processes, we developed a preliminary framework for assessing organizational culture in higher education. The main levels of organizational culture articulated in this model are presented in Table 1.

Table 1
*Levels of Organizational Culture for the IHE Case Studies*

| Levels of organizational culture | Description |
|---|---|
| Institutional culture | Refers to aspects of the UW-Madison campus as a whole |
| College culture | Refers to aspects of specific colleges (e.g., the School of Education) |
| Departmental culture | Refers to aspects of specific departments at UW-Madison |
| Faculty subcultures | Describes the organizational climate at UW-Madison as experienced by individual faculty |

### *Institutional Culture*

Institutional culture refers to cultural processes and artifacts of the UW-Madison as a whole, as opposed to its constituent parts (e.g., college or department).

At this level, there may be many observable artifacts, such as the recruitment, tenure, and promotion (RTP) guidelines of the four cross-campus divisional committees. However, there are fewer individual or collective practices because such a large institution rarely acts as a unified unit.

It is clear from our interviews, document analysis, and observations that UW-Madison is perceived first and foremost as a research institution and that the accomplishments of researchers are a major source of institutional pride, funding, and policy development. Our analysis confirms that, across this institution, most faculty consider research the first priority, teaching a close second, and service to the community or the state a distant if not invisible third. If and when service is considered either in faculty interviews or observed interactions, it is often related to committee work at UW-Madison or service to a professional association. As one respondent noted, in keeping with the valued tradition of faculty autonomy, individuals may choose how to interpret their obligations to the Wisconsin Idea, whether it be outreach to K–12 or serving as a peer reviewer for an academic journal.

### *College Culture*

College culture refers to cultural processes and artifacts at different colleges, such as the School of Education or the College of Agriculture and Life Sciences. Cultural artifacts at these levels are easily obtained and analyzed, but as at the institutional level, observing and analyzing cultural processes at this aggregated level is more challenging. At UW-Madison, college-level artifacts include the RTP guidelines and the outcomes of assessment systems that are developed at this level and that reflect the shared priorities of the departments making up each college. Cultural processes at this level include, for example, the historical division between the School of Education and the College of Letters and Science. Respondents explained that this division is based on “prejudices and biases" that transcend individuals and academic departments and influence the behavior of many faculty.

### *Departmental Culture*

Departmental culture refers to the cultural artifacts and processes at the academic department level. Since the governance system at UW-Madison emphasizes the autonomy of the academic department, understanding the culture of the department is extremely important. The cultural artifacts visible at this level include the RTP guidelines and outcome assessment procedures that each department is free to determine on its own. Cultural processes include the negotiation of these policies and internal politics and divisions. In addition, cultural processes at the departmental level include the shared values and practices related to the academic discipline, which in turn are inextricably linked to the research paradigm of the discipline. Respondents presented many observations about the culture of their departments, particularly regarding how it changes over time. Some STEM faculty reported shifts in how their departments have approached the role of teaching in faculty life and in tenure reviews. For example, one respondent noted that a person in his department was recently denied tenure due to his admittedly poor teaching, which would not have happened in the past.

> Right, so those are big-time cultural signals because when I arrived here in '76 I was told, I think it was in genetics, that there was a department vote whether to recommend somebody for tenure and one of the senior members got up and said, "I'm a little worried because his teaching is pretty good, and that means he's wasting time. So I'm not too sure it's a good idea to tenure him because we might not get the research productivity. We would [rather] somebody who knows how to properly ignore the teaching and just get it done." (Math faculty)

Another respondent reported that he personally had experienced a shift in his department's approach to teaching and in the degree of importance it places on teaching in the hiring process. Respondents also presented different theories about what makes different departments more or less amenable to change. Some opined that it was the discipline, whereas others believed it was departmental leadership or the history of the department.

### *Faculty Subcultures*

Studies of faculty subcultures have considered groups defined by role (e.g., department chairs, junior faculty) or ideal types based on character (Kuh & Whitt, 1988). Here, we use subcultures to mean groups that regularly interact; develop a distinct identity based on shared research interests, political persuasions, or beliefs, values, and attitudes; and share conceptions of problems and their solutions. Our data indicate that subgroups defined in this way are more likely to be the locus of change efforts, or resistance to change efforts, than are groups defined by subdiscipline, roles, or personality types.

For example, some respondents noted that only a small fraction of their colleagues were interested in teaching reform or K–12 issues. The main reasons for this include the overwhelming workload of a faculty member and a lack of interest in these issues. Yet, they reported that a minority of their colleagues nonetheless are interested in these issues and manage to find the time to act on this interest by seeking new resources, assistance, and opportunities to practice in new venues. It is members of these departmental subgroups interested in teaching reform who attended the 2006 UW-Madison Teaching and Learning Symposium.

### *Other Components of Organizational Culture*

Not every aspect of organizational life at an IHE can be adequately explored using the main levels of organizational culture described above. Other components are articulated in our model, as listed in Table 2.

Table 2
*Other Elements of Organizational Culture for the IHE Case Studies*

| Other elements | Description |
|---|---|
| External environment | Refers to societal, political, financial, and cultural forces in which UW-Madison and its faculty exist |
| Research centers | Refers to research centers and units outside of the official college or departmental structure |
| Reform projects | Refers to institutional reform efforts such as SCALE |
| Individual practice | Refers to the practices of individual faculty |
| Paradigms | Refers to discrete traditions of scientific research and practice, including disciplinary paradigms and teaching/learning paradigms |

#### *External Environment*

Some facets of the broader society, such as NSF's broader impacts (Criterion 2) policy, influence individual faculty practices but cannot be described as part of the UW-Madison organizational culture. National policy factors such as this constitute environmental stressors and opportunities for an IHE.

#### *Research Centers*

UW-Madison is well known for its research and education centers that generally are founded and operated with external funding that faculty procure for their research activities. These centers may be loosely affiliated with a department, but they usually operate independently of any department's policies and practices. One respondent noted that once faculty are engaged in research activities at these units, new opportunities for networking, collaboration, and continued funding open up to them. Additionally, operating at a research unit affords faculty a certain degree of status.

An example of an education center that frequently was mentioned by respondents for this case study is the Center for Biology Education (CBE), which is housed in and partially supported by the College of Agriculture and Life Sciences. The CBE frequently provides assistance to STEM faculty in addressing Criterion 2 of NSF funding. Because this resource exists outside of any departmental structure, with its financial and political constraints, it serves as an important resource for UW-Madison and a vital intermediary link between STEM faculty and K–12.

### *Reform Projects*

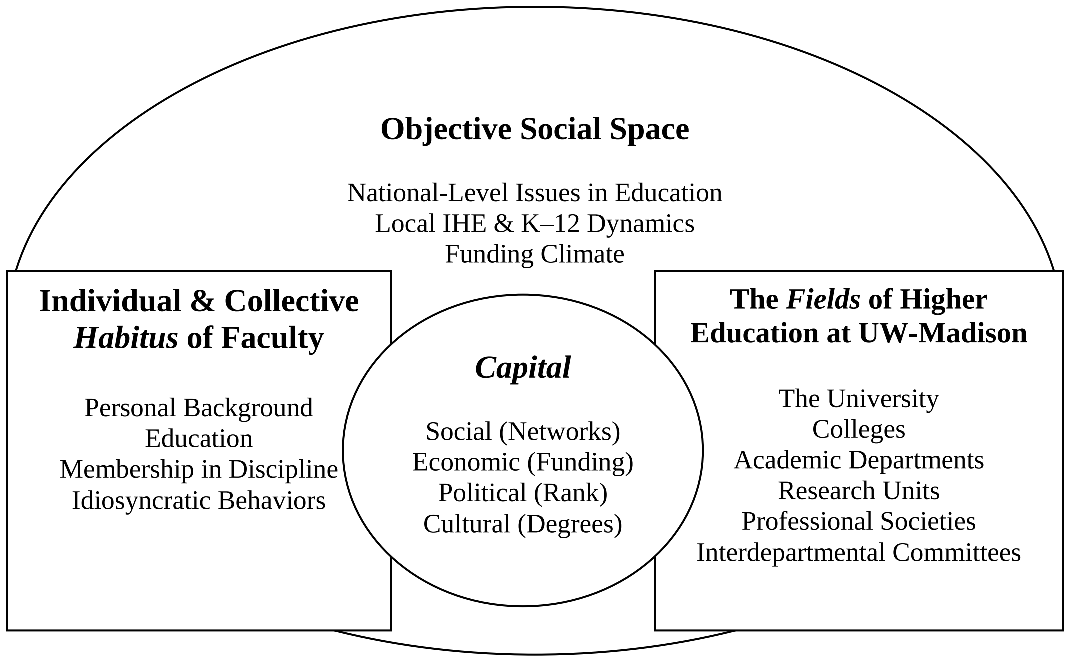
Another organizational unit that operates outside of the usual organizational constraints of a college or department is the reform project, such as SCALE or CIRTL. As previously mentioned, UW-Madison has a long history of involvement with institutional and pedagogical reform efforts that are generally funded by external agencies like NSF. It is important to take account of these projects, which may address issues at various levels within the institution, in an analysis of the organizational culture of IHEs. While they do not operate at the core of IHEs, these projects intersect with and strive to alter core organizational values and practices over time.

### *Individual Practice*

Upon analyzing the data, we found that the concept of organizational culture, as widely used, does not adequately account for individual faculty practice seen in the different venues in which IHE policies, values, and practices operate, and in the many distinct roles that individual faculty play within these venues. For example, our data reveal that senior faculty who had significant external funding, social status within their departments, and professional networks were often the primary participants in SCALE and other reform efforts. Known as *radicalized seniors*, these faculty are able to become STEM education innovators within an unforgiving institutional context, and their examples bear further study (Millar, 2003). For this research, we seek to understand the factors that enable these and other individuals to push the boundaries of the organizational culture at various levels of the institution.

With respect to understanding individual practice, we note that Bourdieu's theory of practice (1977) provides a theoretical framework that helps account for the complex ways in which individual practice interacts with the organizational culture at different levels within IHEs. This framework accounts for the influence of personal disposition and background, known as *habitus*, and the role of an individual's social, political, and economic *capital*, each of which is shaped and constrained by the social and institutional context in which activity occurs, known as the *field.* (See Figure 1.) We introduce this framework here to provide an appropriately flexible analytic lens through which to understand change processes at UW-Madison, and we will explore it in greater detail in Phase 2 of this research.

***Figure 1*. Visualizing the agency of individual faculty within the organizational culture of UW-Madison.**




The primary *field* of practice that influences SCALE operations at UW-Madison is that of a Research I university. The Research I label permeates the entire university by reinforcing the importance—and to some, the superiority—of research activities in STEM departments. The dominance of the Research I identity is manifested in official UW-Madison documents and reports, interdepartmental divisions over teaching reforms, and RTP guidelines that generally prioritize research accomplishments over teaching and service except in unique circumstances. Interviewees also articulated differences between the STEM and education disciplinary fields as key *fields* (in Bourdieu's sense) in their professional lives. Each discipline has unique methods, practices, and characteristics that shape the beliefs and behaviors of its members over time. These differences shape individuals' *habitus* and inform, for example, their views on teacher education and K–12 issues. In this example, they help form opinions on which department is ultimately responsible for educating future teachers, the required coursework for teacher candidates, the appropriateness of IHE faculty participation in K–12 issues, and the role of content-based pedagogy. Some respondents presented these views as relatively intractable and as reasons for the presence of practical and conceptual boundaries among IHE departments and between IHEs and K–12 districts. These boundaries figure prominently in understanding the *field* in which reform projects, such as SCALE, operate.

Despite these barriers, certain aspects of the *field* of higher education in general, and of UW-Madison in particular, provide faculty with the ability to participate in reform initiatives such as SCALE. Academic life at UW-Madison is characterized by an ethos of autonomy that enables faculty to act in accordance with their *habitus* despite limitations of the institutional *field*. For example, many STEM faculty are sufficiently interested in participating in the teacher education program, based on personal experiences with K–12, that they participate significantly in teacher education issues. They do this with impunity as long as they maintain their demanding academic workloads. Additionally, faculty who have substantial social or economic *capital* often enjoy a degree of freedom and status that allows them to participate in more controversial efforts that attempt to alter the constraints of the *field*. In most cases, these faculty are tenured, as tenure is an extremely strong limiting factor of the academic field. In addition, they usually have relatively high status within their department and college, extensive professional networks, or large amounts of external funding. Several respondents also emphasized the value of avoiding barriers posed by conflicts between departmental *fields* and individual *habitus* by fostering collaborations in a "neutral space," such as research or education centers, where institutional constraints and disciplinary disagreements can be minimized. Phase 2 of the UW-Madison case study will further explore these key themes and issues and focus on more detailed questions formulated in this preliminary study.

### *Paradigms*

Disciplinary traditions and practices exist independently of the various organizational cultures at UW-Madison. For example, while the field of chemistry or physics may take on a unique character at a given campus, the discipline itself carries with it certain tenets that are not subject to any particular IHE. For purposes of accounting for the important influence on UW-Madison organizational life of these traditions and practices, the research paradigms of individual disciplines and of teaching and learning are included in this analysis (Kuhn, 1970).

It is useful to revisit the notion of paradigms, since it is clear that what SCALE is attempting to change is not only a model of scientific practice and research (scientific teaching), but also the institutional context in which individual and shared behaviors and beliefs are shaped, constrained, or freed. Paradigms are models of scientific practice comprising laws, theories, applications, and instrumentations, from which "spring coherent traditions of scientific research" (Kuhn, 1970, p. 10). As students become members of a particular scientific community, they join colleagues who learned from the same scientific models and practices. Subsequent practices will "seldom evoke overt disagreement over fundamentals" (Kuhn, 1970, p. 11), since the practitioners are committed to the same rules and standards for scientific practice.

SCALE is not attempting to change the paradigm of scientific research in the STEM disciplines. Instead, SCALE and other reformers view the role of STEM faculty in higher education in two distinct arenas, research and teaching, and focus on change in the teaching arena. They argue that for STEM faculty, teaching is generally viewed as such a simple and non-intellectual matter that it does not merit its own "model of research." It is precisely the paradigm of education research that reformers want STEM faculty to recognize and use in their own classrooms. For some, a strategy is to describe this body of research as just as scientifically rigorous as their own disciplines or to attempt to paint education research within the same paradigm as the STEM disciplines (Handelsman et al., 2004). Those holding the latter view refer to the principles and findings of science education as *scientific teaching* and emphasize that it is approached "with the same rigor as science at its best" (Handelsman et al., 2004, p. 521).

### *An Initial Map of the Organizational Culture of UW-Madison*

In order to understand the entirety of organizational culture at UW-Madison, and to articulate the specific levels and constituent parts of this culture, we developed a preliminary map of the organizational culture (Figure 2). This graphic is intended to portray the different types of cultures in play at UW-Madison and the points in the system where SCALE is leveraging its resources to effect change.

## F. PRELIMINARY CONCLUSIONS

At this preliminary stage of the research, it is possible to make a few summary observations about initial SCALE outcomes, barriers and supports to SCALE, the SCALE strategies for change, and institutionalization processes at UW-Madison. The next steps for this research, including additional research questions, are also discussed in this section.

### Initial SCALE Outcomes

Preliminary findings indicate that SCALE is making progress in each of the four broad IHE-related goal areas of the MSP program and of SCALE, and in each of SCALE's specific goals. Phase 2 of this case study will examine in further detail the outcomes of SCALE at UW-Madison, and the extent to which these are integrated into the core operations of the university.

#### *Institutional Changes*

- In collaboration with MMSD, SCALE is creating a new, substantive relationship between the UW-Madison Mathematics Department and MMSD administrators, math educators, and individual teachers that may lead to changes in the pre-service curriculum and in the design, implementation, and support of professional development in math.

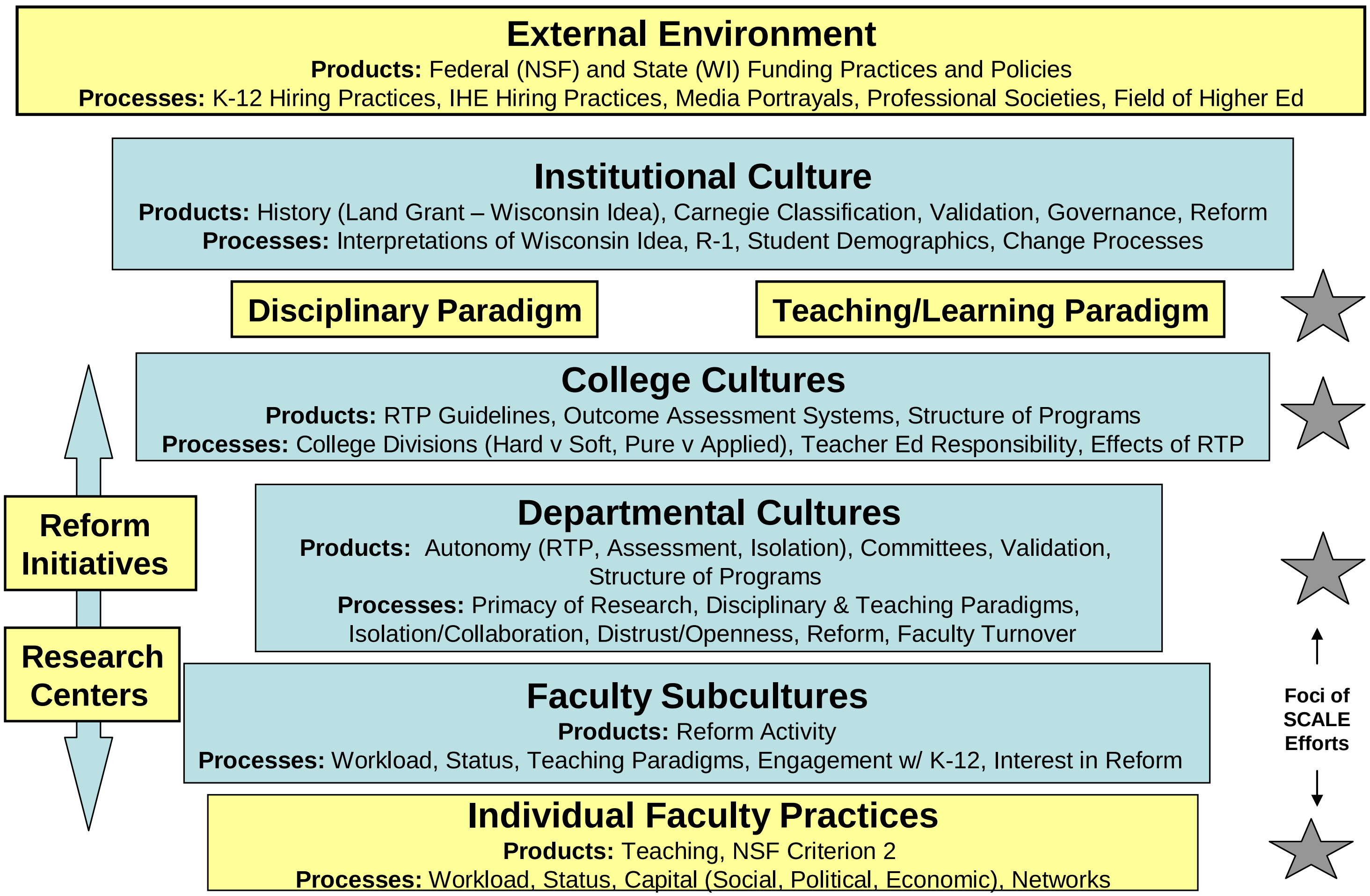
- In collaboration with the School of Education's Teacher Education as an All-University Responsibility Project, SCALE is leading interdepartmental efforts to revise the pre-service math and science curriculum for elementary and middle school teacher candidates.

- Through the co-construction of professional development materials and the co-facilitation of the professional development institutes, SCALE is introducing a new, more collaborative, and mutually beneficial partnership between UW-Madison and MMSD.

#### *Individual Changes*

- Through Math Masters, SCALE is engaging STEM faculty in learning and modeling inquiry-based pedagogy. This project is influencing some participating faculty's

**Figure 2: The organizational culture of teaching and collaboration at UW-Madison**



appreciation for the depth and difficulty of the Connected Math curriculum, K–12 conditions, and the need for continued involvement with K–12 professional development.

- Through Science Immersion Unit design, IHE faculty and staff (at UW and elsewhere) report a newfound appreciation for the *science for all* movement and the importance of designing professional development curricula that engage all student learners, not just the most promising.

## Barriers and Supports to Reform at UW-Madison: Organizational Culture

Interview respondents frequently used a normative concept of organizational culture when explaining how elements of the UW-Madison structural and social context either precluded or facilitated change. Based on our data, it is evident that this normative concept of culture does not adequately model the many different venues in which IHE policies, values, and practices operate and the many distinct roles that faculty may play within these venues.

We therefore employed a new definition of organizational culture, one that encompasses official policies (such as tenure guidelines) and patterns of beliefs, values, and practices at institution-wide, college, department, and faculty subculture levels. This research identified indicators of organizational culture at these different levels that either inhibit or support reform efforts such as SCALE. We will continue to monitor these indicators for the duration of SCALE activities in order to document any changes in policies or practices at UW-Madison and to assess if and how SCALE contributed to these changes.

Furthermore, findings from Phase 1 of this research reinforced the importance of understanding how individual faculty negotiate their organizational cultures, taking into account the differences in individuals' ability and freedom to engage with and support initiatives such as SCALE. Identifying how faculty negotiate and alter the constraints of their organizational cultures will be a major focus of Phase 2 of this case study. For example, the role of social, political, and financial capital in enabling faculty work to negotiate their organizational cultures through enhanced status and autonomy within their departments will be a focus of Phase 2.

## The Challenge of Institutionalization

A preliminary assessment of the approaches to change that SCALE actors are enacting at UW-Madison seems to indicate that instead of radical reform, SCALE leaders are focused on "planting small seeds" of change at various points in the system. These efforts are focused on individual faculty, whose exposure to new pedagogies may bear fruit in later years and in unforeseen ways, and on department- and college-level committees, in which change is a long-term proposition and the pieces are just now being put in place to effect change in coming years. For the purposes of evaluation, it is worth noting where SCALE decides to leverage its financial and human resources and to investigate the efficacy of its particular approach to systemic change for each of its activities. This preliminary phase of the research only sketches the broad outlines of these efforts. Phase 2 of this case study will investigate in greater detail the outcomes and efficacy of these approaches to change. In particular, we expect to focus on the following topics related to institutionalization.

### *The Role of Radicalized Seniors and Reformers*

Initial findings suggest that most of the IHE faculty involved with SCALE and similar reform efforts are members of small cross-college groups of reform-minded faculty who tend to become involved in multiple initiatives. Additionally, they tend to be tenured faculty who enjoy a certain degree of social and professional status. Using Bourdieu's theory of social practice, we can understand how and why these faculty are able to participate in SCALE. This understanding may lead to identifying strategies that enable other, less senior faculty to bypass the constraints at different levels of organizational culture.

### *Careful Negotiation of Boundaries*

One of the primary factors inhibiting interdepartmental collaboration between the School of Education and STEM departments is a historical and persistent mistrust (Labaree, 2004). This factor is evident in the committees formed by the associate dean of education to revise the math and science pre-service curriculum. However, since these committees operate in a neutral territory outside of the STEM or education departments and have relatively equal representation from each "side," faculty appear to be able to operate in an atmosphere in which the institutional constraints are lessened. It appears that this more neutral atmosphere is achieved because participants are carefully negotiating the boundaries separating their distinct departmental and college cultures (Carr, 2002).

### *Co-Construction of Activities as a Critical Element in Partnership Building*

Based on preliminary findings, it appears that real progress is possible when STEM and education faculty are brought together in a neutral territory that partially negates the traditional divisions in order to work on a discrete activity (e.g., pre-service curriculum reform), motivated by shared values and purposes (e.g., improving pre-service teachers' math and science knowledge). Clifford (2006) reported a similar finding for the middle school immersion units being developed by SCALE participants from the Los Angeles Unified School District, two campuses of California State University, and UW-Madison. Researchers in management studies and other fields have found similar results in studying *communities of practice* (Derry, Gance, Gance, & Schlager, 2000; Greeno, 1998; Lave & Wenger, 1991; Millar, 2000; Wenger, 1998) in which different professional groups achieve success by "working side by side and having common organizational values, which are important bases for knowledge transfer between professional groups that belong to different networks of practice" (Tagliaventi & Mattarelli, 2006, p. 292). Furthermore, as Tagliaventi and Mattarelli (2006) reported, "knowledge transfer across boundaries evokes new kinds of organizational citizenship and behaviors" (p. 293).

The primary points of agreement found in this case study among STEM and education faculty were that (a) pre-service teachers' content knowledge must improve and (b) in-service teachers' content knowledge must improve. There is a realization that the teachers trained at UW-Madison will soon be the in-service teachers that faculty complain about, and thus the groundwork is being laid for perceiving a continuum of educational training. This may be a precursor for K–20 system alignment to develop. Based on this case study, we suggest that the next elements required to make this initial collaboration and agreement continue and to accomplish concrete tasks are (a) leadership and administrative support, (b) actual progress and tangible work, (c) openness to conflict, challenge, and possible changing of minds, and (d) participant networks that draw in new blood and resources.

### *The Importance of Neutral Spaces in Fostering Reform*

Several respondents emphasized constraints in their STEM departments that made enacting teaching reforms difficult, if not impossible. In one case, a teaching load that was experienced as "overwhelming" did not allow the preparatory time that using new methods and curriculum requires. This respondent stated that if the departmental structure were changed to allow faculty to teach in new ways, then several colleagues would be amenable to new ideas, but that "until the structure is there, no one needs extra work." In another case, a respondent observed that the Math Pre-Service Committee was able to function effectively since it met and operated in a "neutral space" where the divisions between math faculty and math education faculty could be temporarily minimized. Several respondents described the value of working in these extra-departmental venues. Of course, in order to participate in these venues, faculty must be able to successfully negotiate their research and teaching demands, which may require departmental support for release time or stipends for summer service work. A question to consider is whether these neutral spaces act to increase the "permeability" of the core operations of the university to new ideas and practices, or whether they remain peripheral and thus ultimately ineffective in fostering change.

## Next Steps

The next phase of this research will focus on investigating several issues raised in this study. These issues lead to a new set of research questions:

- Are SCALE activities influencing the core operations of UW-Madison? If so, how and in what form?

- How many faculty are required in a given department to effect the types of changes desired by SCALE and the MSP?

- What incentives are required for STEM and education faculty to participate in reform activities?

In addition, some of the processes and artifacts of organizational culture at UW-Madison identified in this preliminary stage of research will be monitored and analyzed for the duration of this project. Any changes to aspects of the organizational cultures and paradigms, particularly aspects of the teaching and learning paradigm, will be analyzed, and interviews will be conducted with faculty or administrators knowledgeable about the reasons for the changes. In this way, we will be able to accurately explain changes to the organizational culture.

We will employ a new sampling approach for Phase 2 of this research. Respondents from Phase 1 who were directly involved in SCALE activities will be interviewed again to assess any changes in their practices or their organizational cultures. In order to adequately attribute the sources of change in various UW-Madison organizational cultures, we will seek new respondents, including administrators who are positioned to identify the causes behind structural or policy changes. Finally, additional IHE faculty who are not engaged with SCALE or other reform activities will be interviewed to gain a better understanding of organizational culture at the departmental level, as this level is emerging as a key leverage point for reform at UW-Madison.

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