Assessment for Learning (AfL) Education Research Scholars: Capacity Building in Mathematics & Science Education

Western Michigan University (WMU) seeks funding in the STEM Education Research Scholars subcategory of Capacity Building for K-12 Discovery Research. WMU's project represents a potent collaboration between three nationally recognized programs: the Evaluation Center, Mathematics Education, and the Mallinson Institute for Science Education (MISE). While these programs are all at the same campus, and faculty interact with one another, to date *no formal effort has been undertaken to develop a learning community committed to both research and training on a pressing problem: how to improve validity, student interest, achievement, and retention in STEM by strengthening the theory and practice surrounding the use of assessments in K-12.* The proposed capacity building project expands on research in assessment for learning (AfL), or "the process of seeking and interpreting evidence for use by learners and their teachers to decide where the learners are in their learning, where they need to go and how best to get there" (Assessment Reform Group, 2002). **One goal** of WMU's project is to bring faculty from all three programs together in a formal cluster, or learning community, to foster the development of research and leadership in evaluation and, specifically, AfL. The **second goal**, which grows from and will draw on the first goal, is to recruit a cadre of five STEM Education Research Scholars into the learning community as doctoral students who will be trained in and conduct research on measurement and evaluation. Each collaborating WMU program has a well-established strand of research, of which STEM classroom assessment is a major area of interest. An area of commonality for the doctoral research projects will be to advance the profession's understanding of the sort of evaluation preparation needed for STEM teachers to effectively use assessment tools. The **third goal,** which will be an outcome of the first two goals, is to expose preservice teachers to assessment models in their STEM coursework, providing them from the start with a natural appreciation and understanding of assessment theory and practice. Exposure to the role assessment plays in both progress and student motivation in STEM classes will in turn stimulate these new teachers to use sound assessment practices once they enter the classroom. *The project goals address both DR K-12 Grand Challenges 1 and 2. First, the research conducted will result in better STEM teacher-training models and tools. Second, the project will increase future teacher education capacity in that future STEM teachers will be better able to increase student learning by being well grounded in the theoretical basis for and practical application of AfL.*

Collaborating Programs

Evaluation Center. The Center's mission is to advance the theory, practice, and utilization of evaluation. Since 2000, the Center's average annual funding from external grants and contracts has been $1.8 million. The Center has a staff of more than 20 of which five, 3 professional and 2 administrative, are directly funded by the University. Personnel have served in university, state, and national leadership roles; published many journal articles, monographs, books, and chapters; and participated in evaluation work in 20 foreign countries. The Center performs research on evaluation practices, formulates and tests theoretical evaluation propositions; develops data-gathering instruments, reporting formats, and evaluation procedures; disseminates results and conclusions; assists clients, including school districts, nonprofit agencies, government agencies, businesses, foundations, and colleges with program evaluation; trains evaluators; and provides leadership in evaluation as a field of professional practice.

The Center houses the *world's first truly interdisciplinary evaluation Ph.D. program*, the Interdisciplinary Ph.D. Program in Evaluation (IDPE), which serves the colleges of Arts and Sciences, Education, Engineering and Applied Sciences, and Health and Human Services. IDPE is based on the ideas that the best way to learn evaluation is by doing it and the best way to develop "thought leaders" in a discipline is to expose them to the best and brightest minds. The program features practice-linked learning in a world-class center of excellence in evaluation; 30 faculty members from 13 academic departments and The Evaluation Center; and a fully tailored, challenging curriculum. The Center also serves as the administrative home for the Joint Committee on Standards for Educational Evaluation; the Committee's chairperson is always a senior Center staff member. The Committee is an international organization of 18 major education institutions that focus on the development and use of standards for educational evaluation. Committee standards serve program, student, and personnel evaluations and are certified as American National Standards by the American National Standards Institute (ANSI).

Mathematics Education. The Mathematics Education Department is a national leader and has one of the largest faculties (eleven) of any comparable institution. The program enrolls 30 master's and 10 doctoral students. Scholarly activities include the development and implementation of innovative curriculum materials, professional development of teachers, and research on student learning and teacher change. Many projects were funded by NSF or the Eisenhower Higher Education Grant Program, including the Core-Plus Mathematics Project (a multiyear high school curriculum development project), the Core-Plus Mathematics Project II (a five-year longitudinal study), the Core-Plus Mathematics Revision Project (a multiyear project to write a second edition of Core-Plus Mathematics), and Renewing Mathematics Teaching Through Curriculum (a Local Systemic Change Project). The program also partners with the University of Missouri and Michigan State University in the Center for the Study of Mathematics Curriculum (CSMC), an NSF-funded national Center for Learning and Teaching committed to advancing the research base and leadership capacity in K-12 math curriculum design, analysis, implementation, and research. Other partners include the University of Chicago, Horizon Research, Inc., and six prominent research associate specialists in curriculum from other universities.

Mallinson Institute for Science Education (MISE). Established in the early 1960s, MISE wants graduate students to become reflective science education practitioners who can adapt and improve their teaching. Eleven MISE faculty hold joint appointments in a science department or the College of Education. MISE began offering a dual admission program in 2006 that blends science content, pedagogical training, and research in teaching and learning science at a level appropriate to prepare college science teachers. Students are jointly admitted to a master's program in biology, chemistry, earth science, or physics and to the MISE PhD program. MISE has 17 full-time PhD students, including the largest entering class (fall 2006, six full-time students). The number of new students will probably double over the next five years. MISE offers a rigorous research-based PhD and has a strong record of funded research. All MISE doctoral students participate in a mentored teaching role, which involves, during their first semester, observing MISE faculty teach an undergraduate science course in their area of disciplinary expertise. The next semester, the graduate student teaches one section of the course, while closely supervised by a faculty mentor. Students receive feedback and guidance from both faculty supervisors and their peers.

Intellectual Merit. Even though there is an acute professional awareness of the need to institute new forms of assessment as a means of improving learning and retention in STEM, research consistently indicates that teachers still do not fully exploit the rich potential of using multiple forms of assessment. The AfL project will spark a change in practice by (1) building capacity for developing and studying the impact of STEM K-12 assessment-for-learning practices, (2) improving assessment in K-12 STEM and college level teacher preparation courses, and (3) by providing models for preservice preparation of STEM teachers through development and study of enhanced teaching modules focusing on assessment practices.

Broader Impacts. The project will integrate doctoral programs across STEM and evaluation faculty and disciplines, provide new tools for STEM classroom assessments, and improve STEM teacher preparation. The tools and research findings will reshape teacher preparation programs and increase STEM achievement in K-12 schools. Improving assessment practices is most promising and effective for the most vulnerable student groups: minorities, low achievers, and those at risk of dropping out. Results will be disseminated in national presentations, textbooks, journals, and through the University's extensive Web system. Dissemination of findings will stress improvements in STEM classroom texts, STEM testing (local, state, and national), STEM teacher preparation texts, and accreditation requirements for teacher training in STEM areas.

Project Description

1) Goals of the project are to:

1) Develop leadership in K-12 assessment-for-learning practices by bringing faculty from all three program areas together in a formal learning community that will foster the development of research and leadership in evaluation and, specifically, AfL.
2) Recruit a cadre of five AfL STEM Research Scholars into the learning community as doctoral students who train in and conduct research on measurement and evaluation. The results of these first two goals will be the development of models of effective AfL practice across STEM disciplines.
3) Expose preservice teachers to assessment models in their STEM coursework, from the start providing them with a natural appreciation and understanding of assessment theory and practice.

2) Rationale

Terminology

To understand the importance of the proposed project, a clear distinction between *assessment of learning* and *assessment for learning* must first be articulated. *Assessment of learning* is a tool that holds students accountable for learning and, more recently, also holds teachers accountable for producing student learning. Teachers often use *assessment of learning* to rate student achievement in the form of grades based solely on tests and quizzes administered at the end of a unit of work or semester. This assessment does little to improve student learning. Research suggests it works against the intended objectives, causing students to avoid science and math coursework based on self-descriptions such as, "I'm just not good at math or science." Assessment of learning, thus, does not promote student recruitment and retention in STEM fields.

Assessment for learning (AfL) is based on the concept that students flourish when they understand the goal of their learning, where they are in relation to this goal, and how to close their gaps in knowledge (http://www.qca.org. uk/7659.html). Key AfL elements are effective questioning

techniques, shared marking and feedback strategies, shared learning goals, and the use of peer and self-assessment (http://www.qca.org. uk/7659.html). AfL is particularly successful in increasing student motivation and performance when teachers are trained and had administrative support while implementing changes in their classroom assessment practices.

Literature Review

Two major trends that characterize changes and developments in assessment in STEM education over the last two decades are *a shift to multiple forms of assessment* to better understand students' learning *and* the use of assessment for accountability (PSSM, 2001; NCR, 1996). These developments have created a greater appreciation for the multiple ways students master the difficult concepts encountered in STEM classes. The vocabulary of assessment (performance, authentic, alternative, balanced, and portfolio assessments) has become identified with specific classroom practices (tasks, rubrics, questioning, discourse, open-ended problems, and problem solving). Kulm (1994) suggested, "The primary reason for changing the direction of assessment has been to focus on problem solving as a key part of the mathematics curriculum. Continued efforts are aimed at moving beyond simple word problems toward evaluating the processes that students should use in a variety of situations" (p. 25).

The second trend, *assessment as accountability* in the form of annual testing of students at various grade levels (NCLB, 2003), has become a cornerstone of national education policy. Arguments for testing reflect low performance of U.S. students on National Report Cards (c.f. NAEP, 2003) and in International Comparison Studies (c.f. TIMSS, 2003) in STEM areas. States have written STEM standards and benchmarks to be in alignment with the 1989 NCTM *Curriculum and Evaluation Standards for School Mathematics* and the *Assessment Standards for School Mathematics* (NCTM, 1995) and the *National Science Education Standards* (NRC, 1996). They revised state tests to reflect the new goals for students (c.f. State Curriculum Standards, 2007). *The Student Evaluation Standards: How to Improve Evaluations of Students* continues this theme within the evaluation framework (JCSEE, 2003). While the usefulness of these tests in closing U.S. student achievement gaps or in making them more globally competitive is still in question, most teachers freely acknowledge the impact of state testing on classroom practices.

In spite of an awareness of the importance of AfL, the development of new classroom assessment practices, and the pressure on teachers to improve student performance on state achievement tests, educators still struggle with exactly how to use AfL as an integral tool to improve the education of all students. Many STEM "grades" are still assigned, and learning narrowly defined, solely by quizzes and tests. Senk et al. (1997) found that tests and quizzes accounted for 77% of student grades studied in five high schools in three states. "Test items generally were low level, were stated without reference to a realistic context, involved little reasoning, and were almost never open-ended" (p. 187). Only small shifts toward multiple and more complex forms of assessment were found in about two-thirds of the classes. The teachers' knowledge and beliefs and the instructional materials available to the teachers were critical factors associated with these small changes (p. 210). Professional development focused on assessment and other forms of exposure (e.g., through curriculum) to examples of broader assessment measures and techniques were suggested as ways to impact teachers' practices and perceptions (Senk et al., 1997).

Preservice teacher education programs are aware of the need to help teachers move from simple diagnostic assessment practices to more robust packages of assessment for learning techniques,

but lack proven models for how to proceed. The PIs collaborating on the proposed project are convinced the way to achieve the successful use of AfL in K-12 STEM classes is to develop several overlapping learning communities devoted to research and leadership in evaluation, a new graduate training and research program focused on AfL, and demonstration and testing of new models of preservice STEM coursework for future STEM teachers that incorporate AfL.

3) Anticipated Products

Leadership Development and Capacity Building. The project will promote leadership development related to K-12, undergraduate, and graduate evaluation and assessment. The project will develop and enact programs and activities to prepare individuals to assume leadership roles in education with expertise in assessment and evaluation for learning practices. Faculty will recruit, train and support the AfL STEM Research Scholars in their study of assessment and evaluation practices at the K-12 and undergraduate levels of education.

Five AfL STEM Research Scholars will have expertise in formative assessment techniques in their discipline (science, math, or evaluation) and, given our cohort model, also will have experience in and be ready to collaborate with partners across disciplines. This outcome is uniquely available because of the cross-disciplinary nature of our proposal. We anticipate that each student will publish three to five journal articles, either individually or in collaboration with mentors and other students, that will address specific research questions. This represents an important product: advancement for the field. The Research Scholars will make presentations at national meetings. The combined effect of their scholarly communications will be to produce an increased awareness and understanding of the positive impact that AfL can have in STEM.

In addition to the five AfL STEM Research Scholars, we expect 20-30 additional graduate students to also enroll in the courses and the colloquia centered on AfL research and teaching. This result in a cross-disciplinary graduate learning community that will establish a larger culture of deep thinking about the ways AfL can advance STEM teaching and learning.

Preservice Coursework Changes. First, **guides to curricular/pedagogical changes** in the courses and institutional changes in terms of improved methods courses will influence the pedagogy of WMU's STEM faculty. Second, **our graduate students train preservice K-12 teachers**. We estimate that, during the course of the funding period, our graduate students will teach 500 preservice teachers, modeling and demonstrating formative assessment techniques they can incorporate into their future classrooms.

4) Work Plan

WMU's AfL project will implement its three goals in a sequential and yet overlapping manner. **Goal One**, to develop leadership in K-12 assessment-for-learning practices by bringing faculty from all three program areas together in a formal learning community that will foster the development of research and leadership in evaluation and, specifically, AfL, will be the first priority. Faculty from the three programs (see Personnel, listed and described below), led by Dr. Arlen Gullickson, will meet regularly to discuss research and current issues in AfL; to determine selection criteria for the AfL doctoral students; and to participate in the program's recruitment and admissions efforts. A common meeting ground will be the weekly Evaluation Café, where presentations of common interest will be provided for discussion and thought over a “brown-bag” lunch. Once the AfL STEM Research Scholars arrive at WMU, the Café will serve the additional

function of helping them develop camaraderie and new ideas and will help students gain understanding and respect for critical inquiry of others.

The faculty learning community will thus, by definition, implement **Goal Two**, the recruitment of five doctoral students, or AfL STEM Education Research Scholars, to be trained in and to conduct research on measurement and evaluation. Scholars will take courses together, participate in the Evaluation Café, and interact with other STEM graduate students. In the process, they will coalesce to form a second learning community. Each student will be mentored by a faculty member within their chosen discipline and will engage in AfL research projects. Finally, each student will learn an essential skill for their future academic careers: how to write grant proposals.

Goal Three, to expose preservice teachers to assessment models in their STEM coursework, providing them from the start with a natural appreciation and understanding of assessment theory and practice, represents a natural outgrowth of the first two project goals and will occur as the doctoral students begin teaching STEM classes. Faculty in the collaborating disciplines have agreed to open their classrooms for observation of their classroom practices, which will facilitate the research component of the project, and also have agreed to allow their courses to be used to implement and evaluate new AfL tools, which will facilitate the project's ability to achieve goal three.

STEM AfL Education Research Scholars. Over a five-year period, the project will fully support a cadre of five doctoral students who will train in the areas of measurement and evaluation with respect to learning achievement and conduct associated research. The project builds existing doctoral programs in Evaluation, Mathematics Education, and Science Education. Students will be admitted under one of three program emphases:

1) Interdisciplinary Evaluation doctoral program. These AfL Education Research Scholars will conduct research in the context of mathematics or science education and develop expertise in general evaluation.

2) Mathematics Education doctoral program. These AfL Education Research Scholars will develop expertise in evaluation within mathematics education.

3) Science Education doctoral program. These AfL Education Research Scholars will develop expertise in evaluation within science education.

Each program requires a core set of research methods courses (12 hours). The evaluation core courses are research methods and evaluation courses of a sort also required by MISE and math education as core requirements. Evaluation AfL Education Research Scholars will take STEM courses from either the core math or science doctoral programs, and the MISE and math doctoral students will take their research and evaluation methods from the discipline core in the evaluation program. The Interdisciplinary Evaluation Seminar will be their principal point of contact, though they will also take some of the other Research Tools courses as a cadre. As explained in the table below, AfL Education Research Scholars will become members of two learning communities. The first will arise from their common coursework and will span both assessment for learning and their discipline. The student learning community will also join the learning community initiated by the AfL faculty to focus on AfL research and development.

The following table gives explicit details about the common core as well as the three subspecialties. The *Interdisciplinary Evaluation Seminar* will be the major common point for the program because it will introduce students to AfL research and will be the forum for thinking about AfL research projects. It is a 1 credit course offered each semester for up to 4 credit hours, and is designed to stimulate students to integrate and reflect on the evaluation-related knowledge gained from their other doctoral-based studies and research. The class also will function as a forum for STEM AfL Research Education Scholars to engage with doctoral students from other programs, evaluation specialists, and faculty members. As the AfL Scholars are introduced to AfL research, they will participate in research projects. Some projects will serve as part of their training, while others will develop into dissertation topics. Our research capacity is described in the next section.

<table>
<tr><th colspan="3">Common AfL Research Core (12 hours)</th></tr>
<tr><td colspan="3">All doctoral students at WMU are required to complete 12 hours of Research Tools. Allowing for some variation*, the AfL Education Research Scholars as a cadre will take:

Elementary Statistics (3 hours)
Several departments at WMU offer appropriate courses, including Education, Mathematics, Psychology, Sociology and Statistics.

Qualitative Research Methods (3 hours)
Offered by the College of Education

Advanced Applications of Measurement Methods (3 hours)
Offered by the College of Education, Psychology and Statistics

Research Design (3 hours)
Offered by the College of Education, Psychology and Statistics

Interdisciplinary Evaluation Seminar (1-4 hours)
Offered by the WMU Evaluation Center

* Note: Mathematics Education requires competency in three tools such as SPSS, SAS, Fathom, Geometer’s Sketchpad, or other approved technology.</td></tr>
<tr><th colspan="3">Program Area Specifics</th></tr>
<tr><th>Mathematics Education</th><th>Science Education</th><th>Interdisciplinary Evaluation</th></tr>
<tr><td>Math 6510 Studies in Teaching Elementary Mathematics (3 hrs.) This is an advanced methods class devoted to analysis of current theoretical and research-based perspectives on mathematics teaching and learning and their implications for instructional practice and evaluation of student performance at the elementary level. Specific attention is given to the impact of technology on the teaching/learning process.

Math 6520 Studies in Middle School Mathematics (3 hrs.)</td><td>SCI 6140 Science: Historical and Philosophical Perspectives (3 hrs.) This course utilizes work in the history and philosophy of science to provide a critical perspective for dealing with the question: "What about science is most important for students to know?" The course will address the nature of scientific disciplines (the theory and problems that characterize them); the relations between theory and empirical work; and the nature of theory change in the sciences. 6140 is meant to provide a broad foundation for subsequent</td><td>EVAL 6000 Foundations of Evaluation

This course is designed to introduce students to the fundamental logic and methodology of evaluation, as it applies to the full range of potential evaluands–including products, services, personnel, programs, projects, policies, interventions, organizations, manufacturing processes, information and communication systems. Topics will include an introduction to evaluation theory and models, needs assessment, the generation of comprehensive</td></tr>
</table>

This is an advanced methods class devoted to analysis of current theoretical and research-based perspectives on mathematics teaching and learning and their implications for instructional practice and evaluation of student performance at the middle school level. Specific attention is given to the impact of technology on the teaching/learning process.

Math 6530 Studies in High School Mathematics (3 hrs.)
This is an advanced methods class devoted to analysis of current theoretical and research-based perspectives on mathematics teaching and learning and their implications for instructional practice and evaluation of student performance at the high school level. Specific attention is given to the impact of technology on the teaching/learning process.

Math 6540 Secondary School Mathematics Curriculum Studies (3 hrs.)
Participants in this course examine curricular issues and trends in secondary school mathematics and analyze recent experimental and commercial curriculum materials. This course is rotated as four different offerings that sequentially focus on algebra, geometry, probability and statistics, and discrete mathematics. Students may take this course more than once provided that no content focus is repeated.

Math 6570 Issues and Trends in Secondary School Mathematics (3 hrs.)
This course examines current policy issues and curricular and instructional trends in secondary school mathematics and related research studies. It is designed to provide a transition to advanced graduate work in mathematics education. Prerequisite: Consent of advisor.

curriculum development, instructional design, and research into the teaching and learning of the sciences.

SCI 6150 Science Education: Historical and Philosophical Foundations (3 hrs.)
This course will familiarize students with the history of science education in the United States, leading up to current national reform efforts. This historical approach will provide a foundation to address curriculum and literacy issues as well as the relevance of history and philosophy to these concerns. The course addresses two themes or "common places" of education in a science education context - the social milieu and the curriculum.

SCI 6160 Science Education: Models of Learning and Teaching (3 hrs.)
In this course we do a preliminary survey of basic concepts and research in the sciences of learning. Research emerging from contemporary cognitive psychology has much to offer education. In SCI 6160 we focus on the connections between cognitive psychology, cognitive science and effective learning. Some of the major theoretical orientations considered are those of Piaget, Vygotsky, the theories of conceptual development, information-processing psychology and connectionism. *AfL material will be added to SCI 6160*

SCI 6170 Science Education: Research Traditions (3 hrs.)
This course is designed to familiarize students with the more productive research traditions in science education and their historical, philosophical and methodological foundations. Each offering of the course focuses upon a particular tradition, for example, problem solving research or

criterion checklists, setting standards, collecting and synthesizing mixed method data, drawing explicitly evaluative conclusions, and the basics of presenting evaluation findings to different client audiences.

EVAL 6010 Interdisciplinary Evaluation Seminar
This seminar will provide a forum for the integration of core evaluation concepts across the program, developing an understanding of evaluation as a profession, and for exchange of ideas among evaluation students, faculty, and industry representatives from multiple disciplines. Topics will include: the history and nature of the evaluation profession, evaluation standards, meta-evaluation, the application of evaluation to different types of evaluand, similarities and differences in evaluation approaches used for different purposes, current issues in evaluation, and needs/opportunities for innovation in evaluation.

Interdisciplinary Evaluation
In addition to the two EVAL courses listed above, IDPE students take courses from across the university curriculum to achieve competency in evaluation-specific logic and methodology; evaluation theory; social, political, and cultural contexts of evaluation, evaluation planning, budgeting, contracting, and management; database design and management; evaluation reporting and utilization; metaevaluation and evaluation standards; and the history and nature of the evaluation profession. Competencies not directly addressed by coursework are developed through practical experiences.

Each student's curriculum is tailored to meet his or her needs and interests. It is anticipated that AfL students admitted to the Interdisciplinary Evaluation program will draw their courses largely from Mathematics Education and Science Education. Below are examples of other courses

Math 6580 Psychology of Learning Mathematics (3 hrs.) This course focuses on theories of mathematical thinking and knowing and on an examination of major research paradigms and research findings, on mathematical learning in children and adults, and their implications for instruction. Prerequisite: Consent of advisor. **Math 6590 Research in Mathematics Education** (3 hrs.) This course focuses on research issues, methodologies, and trends within mathematics education along with techniques for critical analysis of research. Students are expected to design and present an individual research study. Prerequisite: Consent of advisor. **Math 6950 Seminar in Mathematics Education** (3 hrs.) This course is offered periodically and focuses on a current and timely issue in mathematics education such as assessment, mathematics standards, current influential documents within the field of mathematics education, technology issues, or specific mathematical topics of import in K-12 classrooms. Students may take this course more than once provided that no topic focus is repeated.	conceptual change research. The course may be repeated for credit. *One section of SCI 6170 will focus on AfL as a research tradition* **SCI 6180 Teaching and Learning in the College Science Classroom** (3 hrs.) This course will present, analyze and evaluate methods and techniques of teaching science. Topics may include new approaches for teaching science, new science curriculum, laboratory practices, science education research, motivational techniques, and other methodological problems confronting science teachers. Course content may vary, and the course may be repeated for credit provided different topics are involved. *AfL material will be added to SCI 6180* **SCI 6260 Curriculum Studies in Science Education (**3 hrs.) Curriculum Studies in Science Education examines fundamental issues related to science curricula and curricular studies, primarily at the K-12 levels, while utilizing examples from historical and current reform efforts in science education. Students will explore the history of science curriculum reform efforts through current practices. Students will develop expertise in science curriculum analysis, the development of science curriculum materials, including formative assessment. *AfL material will be added to SCI 6260*	that could be part of an IDPE-AfL student's curriculum: **ED 6000 - Fundamentals of Measurement and Evaluation in Education** This course is designed to develop understandings and competencies in educational measurement and evaluation. Emphasis is placed on the application of research techniques to evaluation, the interpretation of quantitative data in educational situations, and the application of basic evaluation models. **EMR 6420 - Program Evaluation** Emphasis is on the theory of program evaluation, on techniques used in program evaluation, and on the standards of quality professional practice. Students are expected to apply the principles of evaluation to design problems. **EMR 6620 - Advanced Seminar in Evaluation** An advanced seminar for the study of theoretical and practical problems in evaluation. Issues of ethics and quality in evaluation are addressed. **ES 6290 - Culture and Schooling** The purpose of this course is for students to examine culture as a system for organizing thought and perception and to explore its various influences on the content and methods of schooling in the United States. Particular attention is given to cultural dissonance among students, teacher, and text, and to culturally grounded ways of knowing that emerge from schooling experiences. **ES 6340 - Culture and Politics of Educational Institutions** This course examines practical and theoretical issues concerning learning organizations. It examines the ways educational aims and practices relate to wider patterns of belief, value, and controversy, and how these emerge and change in organizational settings. It includes consideration of the organizational dynamics of

		institutionalized educational practices, and explores how cultural assumptions influence educational content and method. The course also examines the roles of professional educators in effecting organizational change. **SOC 6870 Evaluation Research** The basic purpose of this course is to familiarize students with the various research techniques for evaluating action agencies through a survey of the literature, study of evaluation models, and study of techniques and procedures used in evaluation.
Dissertation (15 hours)		

The total course load is comparable to the WMU standard mathematics education and science education doctoral program.

Research Capacity at the Evaluation Center crosses many disciplines, but has a strong emphasis on science education. One example is the Materials Development, Training and Service to STEM education project, which developed the widely used checklist site on evaluation and the use of evaluation standards; provided direct evaluation instruction to more than 150 science education evaluators; and, through evaluation internships, the project provided assistance to the Advance Technology Education at NSF and the NASA science education programs in developing and using sound evaluation practices. The Center evaluated NSF's Rural Systemic Initiatives in six regions of the U.S.; NSF's Advanced Technological Education program; NASA's Aerospace Education Services Program based at Oklahoma State University; and a project to raise awareness of the importance of science literacy and develop science curricula for the American Association for the Advancement of Science. Center research has provided ongoing support to K-12 and pre-K education: scoring and related consultant services provided for the National Association of Secondary School Principals' CASE battery of instruments assessing relationships between school inputs and student outcomes; analyses of school effectiveness and efficiency, including possible interventions for school improvement, for the CASE Information Management System; community surveys of public perceptions of local schools; evaluation of curriculum in the South Haven, MI, schools; evaluation of charter schools in Connecticut, Delaware, Illinois, Michigan, Ohio, and Pennsylvania; evaluation of several school- and intermediate school district-based initiatives throughout Michigan; and several projects for Kamehameha Schools in Hawaii. In higher education, the Center recently provided technical assistance to aid WMU in developing a universitywide system of program review; evaluation of the Charter School of Education at California State University; and evaluation of a project at the University of Montana to recruit and retain women science faculty. A more complete description of The Evaluation Center's work in education as well as many national and international fields can be found at the Center's Web site at http://evaluation.wmich.edu.

Research Capacity at Mathematics Education includes a rich history of research in mathematics education across grade bands (elementary, middle, and high school) and foci, including curriculum development, teacher learning and professional development, use of

technology to teach mathematics, and assessment and evaluation. The program has participated in evaluation research connected with the Core-Plus Mathematics Project focusing on student learning in a context- and standards-based high school curriculum embedded with multiple assessment techniques (www.wmich.edu/cpmp). Faculty engage in research on teacher knowledge and implementation of standards-based curricula. They have contributed two chapters to the book, *Teachers' Use of Mathematics Curriculum Materials: Research Perspectives on Relationships Between Teachers and Curriculum* (Remillard, Lloyd, & Herbal-Eisenmann, 2008). The faculty mentor for the AfL project has done evaluation research associated with the Iowa Local Systemic Change Initiative and the NSF-funded *Project to Implement the NCTM-Standard in Discrete Mathematics* based at Boston College. The Center for the Study of Mathematics Curriculum (CSMC) provided a significant stimulus for research in mathematics education focused on curriculum studies. The most recent inventory of CSMC research shows 52 studies in progress or completed by the CSMC leadership team, faculty associates, or research associates from other universities distributed across six broad areas of curriculum interest including student learning, teacher knowledge, design and analysis, adoption and enactment, policy issues, and history. Annotated descriptions of all studies are available in NSF annual reports for CSMC. The CSMC has produced a detailed comparative look at curriculum standards, *The Intended Curriculum as Represented in State-Level Curriculum Standards: Concensus or Confusion?* (Ed. B. Reys, 2007) and is responsible for the design and development of a literature and tools database available as a resource for researchers and practitioners of K-12 curricula.

Research Capacity at the Mallinson Institute for Science Education. MISE is responsible for the 6-course science sequence taken by WMU's preservice elementary and middle school teachers. Content is based on the Michigan Science Framework and the National Standards for Science Education. The dual objectives are to develop K-8 teacher knowledge of science and knowledge of inquiry instruction through a process of inquiry instruction. TheMISE research piece for the proposed project will take place in this context. With these six courses and their numerous sections, we can use randomized designs with the section as unit for randomization: treatment and control randomly assigned to the sections. We can assure good N sizes for quantitative work—especially if we look at research over the course of two years. We can also do qualitative “think aloud” protocols for deep assessment of comprehension. A number of research questions logically follow from our Central Questions. Of particular interest at MISE are the following, and these are the questions on which our AfL Research Fellows would likely concentrate.

Research Question #1: *To what degree does modeling the AfL techniques by instructors of preservice teachers correlate with preservice teacher practice when they are placed in their teaching internship?* Instructors at the Mallinson Institute would be briefed on the listed assessment for learning techniques, then choose techniques that appeal to them to incorporate into their teaching. Trained observers would evaluate the classes and verify the degree to which AfL techniques are used. Preservice teachers would be tracked to determine which MISE instructor(s) they encountered and then, during their teaching internship, would be observed to quantify their use or lack of use of formative assessment techniques. Program analysis would include the degree to which preservice teachers’ techniques correlate to the modeling to which they were exposed.

Research Question #2: *To what extent can conceptual change research serve as the foundation for the development of effective conceptual questions used in the AfL format?* Is the general AfL strategy more effective if formative assessment tools are grounded in conceptual change research? Based on the literature and our own experience, conceptual change instruction appears to be an effective way to develop students' conceptual understanding of science (Hewson & Thorley, 1989; Posner et al., 1982; Savinainen et al; 2005; Scott et al., 1992). It makes sense, then, to tie our formative assessment practices to our conceptual change instructional practices. Graduate researchers will improve the education of K-8 teachers of science by working with science faculty and course TAs to develop and test an AfL scheme based on changes in teaching based on conceptual change approaches within a context of inquiry.

Recruitment and Retention

The Evaluation Center, Mathematics Education, and the Mallinson Institute will feature the AfL Education Research Scholars program in all recruiting efforts for science education. The program will be featured on our Web page with Peterson's Online Guide to Graduate Education and publicized through national and Michigan mathematics teachers, science teachers, and education associations. The WMU Graduate College participates in several Grad College Fairs each year, including those held at Historically Black Colleges and Universities (HBCUs). The WMU Graduate College will feature the AfL Education Research Scholars program at each fair. The program will also be presented on appropriate WMU Web pages and notices placed on list serves of relevant organizations such as AERA, NARST and NCTM.

The Mallinson Institute for Science and Mathematics Education both have good track records of recruiting and graduating women students. Currently, over half of the MISE doctoral students are women. We also have several international students. Currently, one African-American woman is enrolled at MISE with a second African-American woman expected in the fall. We are making a special effort to improve our minority enrollment by contacting the minority caucuses at national organizations. During the past five years all five Ph.D. graduates in Mathematics Education have been women. Of the 10 currently active Ph.D. students in mathematics education, six are women (one from Turkey), two are African-American males, and two are from Pacific Rim countries (one male and one female).

To help insure student success we work very closely with the Graduate Center for Research and Retention at WMU, an innovative center providing sustained one-on-one mentoring, guidance, and advising support to graduate students in all fields. Under the direction of Dr. Marianne Di Pierro, the Graduate Center represents an integrated approach to retention, conducts research on time to degree, participates in national research initiatives in graduate education that ensure best practices, and implements programmatic interventions to enhance opportunities for graduate degree completion.

5. Evaluation.

Norman Webb, Senior Research Scientist Emeritus at the Wisconsin Center for Education Research, University of Wisconsin, will serve as external evaluator. He has served in a variety of positions focusing on research and evaluation in K-12 and higher education. For example, he served as Section Chief, Bureau for Achievement Testing, Wisconsin Department of Public Instruction; Manager of Educational Research and Evaluation, Wisconsin Educational

Communications Board, Madison; and has conducted alignment analyses for over 20 states from 2002-2007. He has authored a wide array of published research articles including, for example, "The Impact of the *Interactive Mathematics Program* on student learning" in S. L. Senk & D. Thompson, *Standards-Based School Mathematics Curricula: What Are They? What Do Students Learn*? Mahwah, NJ: Lawrence Erlbaum Associates, Publishers, pp. 375-398, 2003. He has directed a large number of grants including a recent grant titled "Adding Value to the Mathematics and Science Partnership Evaluations," funded by the National Science Foundation (EHR-0233445), $1,492,919, October 1, 2002, to September 30, 2005.

Evaluation will attend to each of the three Center goals related to AfL research. Because the budget available for evaluation is small, Dr. Webb will specify data to be gathered to serve his evaluation needs but will rely on project staff and doctoral students to regularly collect data as part of program efforts and provide those data to him for his use in analysis and determination of findings. Evaluation will include formative and summative components focused on (1) determining the impact of the program activities on its various stakeholders and audiences (graduate and undergraduate students, conference participants, K-12 educators, etc.), (2) assessing the effectiveness of the various program initiatives and activities, and (3) providing evaluative data to faculty and staff to help improve the program.

Goal One: Leadership Development. As the project's graduate student development and research activities unfold, they will be assessed from multiple perspectives, particularly to determine the effects (added value) of AfL practices on STEM and evaluation instruction to enhance teachers' STEM and pedagogical knowledge. Traditional measures such as surveys, tests, and interviews will be used to determine changes in teachers' and students' knowledge, affect, and perspective. In addition, the work of the project to develop theoretical models, transportable materials, and research/evaluation tools will be studied. Research conducted by the project also will be assessed on the basis of acceptance by the field, that is, the extent to which reports of the studies are accepted for presentation at professional meetings, published in refereed journals, and referenced in the work of others. There also will be continual formative evaluation (with feedback to the project staff) to insure that research plans and studies take careful account of such important issues as diversity and the existence of more than a single ideology.

Goal Two: Recruit and train five AfL STEM Research Scholars. Evaluation will focus on the quality and impact of the AfL doctoral program. Included will be recruitment, provision for learning opportunities, development of participants with AfL interests, and expertise. One aspect of the evaluation will target the project's effort to develop and disseminate a new graduate course that attends to AfL use and related issues in a research-based colloquium course as well as to integrate assessment for learning issues into undergraduate courses as points of investigation. Measures of success will include the quality of the development process, the extent to which the courses are sustained, enrollments both by project-based students and the population of STEM graduate students, and the response of the field to the dissemination efforts. Data will be gathered through on-site visits, interviews, surveys, and examination of appropriate artifacts.

Goal Three: Preservice Coursework Changes. The project is carefully structured around collaborative arrangements. How these relationships develop and contribute to success will be studied formatively and summatively. In particular, the evaluation will target three relationships: (1) cooperation among the three participating disciplines, (2) activities stemming from research

findings involving discipline and methods courses, and (3) the synergistic activities planned between the project and other discipline and research experts.

6. Dissemination:
Dissemination will take place through the Internet, conference presentations, and journal articles.

- An Internet page housed at WMU will specifically support the activities of the AfL Education Research Scholars program and will make available PDF copies of program research papers.
- AfL Education Research Scholars and their mentors will present papers at relevant conferences in evaluation, mathematics education, and science education, including meetings of the Michigan Science Teachers Association, the National Science Teachers Association, and National Council for Teachers of Mathematics; teacher educator meetings such as the Association for Educators of Teachers of Science; and research meetings such as the National Association for Research in Science Teaching, the American Educational Research Association, and the American Evaluation Association.
- AfL Education Research Scholars and their mentors will publish articles in journals such as *Science Education*, the *Journal for Research in Science Teaching*, the J*ournal of the American Evaluation Association*, and the *American Educational Research Journa*l.

7. Personnel - Biosketches have been submitted for all project personnel.

Program Manager - Arlen Gullickson

Evaluation Program
Arlen Gullickson, Program Lead Mentor
Brooks Applegate (Measurement and Research Methods)
Kathy Cummings (Student Assessment)
Lilianna Rodriguez (Evaluation Theory)

Science Education Program
William W. Cobern, Program Lead Mentor
David Rudge (Biology Education)
Herb Fynewever (Chemistry Education)
Heather Petcovic (Earth Science Education)
Renee' Schwartz (Biology Education)
David Schuster (Physics Education)

Mathematics Education Program
Steven Ziebarth, Program Lead Mentor
Ok-Okeong Kim (Elementary Education)
Christine Browning (Elementary Education, Middle School Education)
Dwayne Channell (Middle and High School Education)
Tabitha Mingus (High School and Collegiate Education, Mathematics)
Kirsty Eisenhart (Mathematics)

8. Prior Results
Arlen Gullickson, PI, conducted an evaluation of the NSF Advanced Technology Education (ATE) program (1999-2006) and directs a continuation that annually surveys program projects and centers (2006-2008). He is the external evaluator for the NSF-funded Collaborative Evaluation Communities In Urban Schools (CEC) (University of Kansas and University of Minnesota), and directs a project evaluating the University of Montana Partnership for Comprehensive Equity (an NSF ADVANCE program); is an advisor and mentor for an NSF-

funded project providing professional development in research for historically black universities in Mississippi, the Mississippi Delta Evaluative Research and Capacity Building Project; is an external evaluator for the South Dakota EPSCoR project, funded as part of NSF's Research Infrastructure Improvement Grant Program. From 1996-2004 he led an NSF project that developed an extensive Web site on evaluation checklists (http://www.wmich.edu/evalctr/checklists/). He led development of the *Student Evaluation Standards* (2003), *and co-authored materials such as The Teacher Self-Evaluation Tool Kit* (2006), and *Evaluating the Upgrading of Technical Courses at Two-Year Colleges: NSF's Advanced Technological Education Program* (2004).

Steven Ziebarth contributed to the NSF-funded assessment and evaluation component of the Core-Plus Mathematics Project (MDR-9255257) (1992-1999) that developed a four-year integrated high school curriculum in alignment with the NCTM (1989) curriculum standards recommendations. The first edition of this work, *Contemporary Mathematics In Context*, integrated major strands of mathematics, teaching for understanding, and embedded assessment into a curriculum that now serves as a model for the College Board recommendations for integrated curricula that aligns with their newly released standards. More focused research was completed under the NSF-funded Core-Plus Mathematics Project II (ESI-9618193) (1999-2003), a project that collected longitudinal data of teachers' implementation of the curriculum in three schools whose entering freshmen had completed one of the NSF-funded middle school curriculums. Both early projects collected extensive data on teacher practices related to curriculum implementation and student achievement (c.f. Senk & Thompson, 2003). Dr. Ziebarth is the principal evaluator for the NSF-Funded Core-Plus Mathematics Revision Project (ESI-0137718), a major revision of the *Contemporary Mathematics In Context* curriculum based on research findings on student learning since standards-based curricula emerged in the 1990s. Dr. Ziebarth also is co-PI of the NSF-Funded Center for the Study of Mathematics Curriculum (CSMC) (ESI-0333879), now in its fourth year of funding, with major goals of capacity building in curriculum research and development of doctoral programs and research opportunities in curriculum studies. To date across the three university sites that comprise its core, the Center has 30 active doctoral fellows working on dissertations in curriculum studies; developed five new doctoral courses to enhance the program; and engaged them in a wide range of curriculum.

William Cobern was past PI for an NSF-RED (#9055834) grant, co-PI for an NSF-Bridges (#0230654) and NSF-STEMTP (#0202923) grant. Currently, he is co-PI on an NSF-STEP (#0336581) project to improve recruitment and retention of minority students in STEM majors, which has had good results so far. He is PI for an NSF-IERI (#0437655) research project using experimental methods to test the effectiveness of popular science teaching approaches. The third trial will be held this summer, with two more to come. Last, he is co-PI on an NSF-ASA (#512596) assessment project for the development of improved ways to evaluate teacher knowledge of science instructional best practices. **Other members of MISE** hold federal funding in physics education and earth science education. The total R&D funding at MISE exceeds $4M.