



University of Missouri
Science Education Center

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GOAL AREAS

1. RESEARCH
2. OUTREACH
3. UNDERGRADUATE EDUCATION
 - Science teacher preparation
 - College science teaching
4. GRADUATE EDUCATION

**MU SCIENCE EDUCATION CENTER ANNUAL REPORT
 JUNE 2008 – JUNE 2009**

The MU Science Education Center (MUSEC) has at the core of its mission (see back cover) to improve science teaching and learning for all. This annual report celebrates the successes of the MU Science Education Center during the 2008-2009 academic year. We highlight our activities aimed at achieving the MUSEC mission in four areas: 1) research; 2) outreach to K-12 schools; 3) undergraduate education, including science teacher preparation and college science teaching; and 4) graduate education. MUSEC was established in 2001 with funding from Mission Enhancement through the collaboration among four MU units: Department of Learning, Teaching and Curriculum (College of Education), Division of Biological Sciences and Department of Physics & Astronomy (College of Arts & Sciences), and the Department of Biochemistry (College of Agriculture, Food and Natural Resources).



MUSEC faculty, graduate students, and alumni at the 2009 National Association for Research in Science Teaching Annual Meeting in Garden Grove, California.

MUSEC GOALS

1. To research K-16 science teaching and learning and contribute to the knowledge base in the field. (RESEARCH)
2. To improve K-12 science teaching and learning. (OUTREACH)
3. To improve undergraduate education for science teaching majors, science majors, and non-science majors. (UNDERGRADUATE EDUCATION—SCIENCE TEACHER PREPARATION and COLLEGE SCIENCE TEACHING);
4. To help prepare science and science education graduate students to be active participants in continuing the reform of K-16 science education. (GRADUATE EDUCATION)

RESEARCH

The seven MUSEC Science Education faculty members had a productive year, with a total of 26 publications: 11 papers in research journals (including the top tier *Journal of Research in Science Teaching* and *Science Education*), 13 papers in practitioner journals (including *American Biology Teacher* and *Science and Children*), and 2 book chapters. Current and former graduate students were co-authors on 13 of these publications. In addition, faculty members and graduate students

presented 40 papers at 14 different international and national meetings and 3 regional meetings. This section highlights two publications as examples of the important scholarly work produced by MUSEC faculty and students. We also describe a new NSF- funded science education research project, our international research presence, and MUSEC graduate student contributions at NARST. A full account of our publications and presentations can be found in Appendix B, which starts on p. 21.



RESMAR²T TEAM PUBLISHES IN JRST

Dr. Friedrichsen led a team including Drs. Abell and Volkmann and GRAs Pat Brown, Deana Lankford, and Enrique Pareja on research published in the *Journal of Research in Science Teaching*. The researchers examined the effect of prior teaching experience on knowledge for teaching among students in our alternative certification program. They compared the incoming knowledge of students with no teaching experience to those with two years of secondary

teaching experience. They found that, in the absence of teacher education, teachers developed general pedagogical knowledge; however, they failed to develop science topic-specific knowledge critical to supporting science learning. This study lends support to the importance of science teacher education and refutes the claims that strong subject matter is enough to make high quality teachers and that teachers learn what they need to know on the job.

GOAL: To research K-16 science teaching and learning and contribute to the knowledge base in the field.

VOLKMANN PRESENTS TO DUTCH RESEARCHERS

In March, 2009, Professors Volkmann and Abell were invited to present their research at the University of Leiden in the Netherlands. Volkmann's talks focused on the kinds of knowledge that future science teachers need to be effective, and ways in which to structure teacher education programs to help future science teachers learn. The Dutch researchers were interested in how

knowledge for teaching develops among teachers from various disciplines. Volkmann and Abell were hosted by Dr. Jan van Driel, who visited the MU Science Education Center in 2008. MUSEC faculty members have collaborated with van Driel on a variety of research and writing projects involving science teacher knowledge development.



Professor Volkmann with Jan van Driel of the University of Leiden after his talk.

RESEARCHING INNOVATIVE ASSESSMENTS

Dr. Siegel is PI of a new NSF CCLI grant entitled, "Addressing the Assessment Gap in Undergraduate Science: Development of Innovative Assessments for Learning in Biotechnology (DIAL-B)." The Dial-B research team includes Co-PI's Drs. Freyermuth and McClure, Biochemistry, and GRAs Steve Witzig and Carina Rebello, Science Education. The purpose of the project is to design and research reform-based assessments for college biotechnology courses. The research team piloted assessments and innovative

strategies in Dr. Siegel's Biochem 2112 (*Biotechnology and Society*) course in Spring, 2009. During the summer, they analyzed data, developed additional assessments, and organized an expert review of the assessments. In Fall, 2009, they plan to collect data from several sources in Dr. Freyermuth's section of Biochem 2112. This project will produce: 1) a resource bank of assessments, 2) a model for how to design assessment, and 3) findings about how to use assessments in the college classroom.



The Dial-B research team in action: Drs. Freyermuth, Siegel, McClure and GRAs Witzig and Rebello.

STUDYING UNDERGRADUATE SCIENCE AT MU

In fall, 2008, MUSEC alum Meredith Park Rogers, and co-author Abell published a study in the top tier journal, *Science Education*. The purpose of this study was to understand one case of college inquiry based instruction. The context of the study was MU's *Warm Little Planet* course. The researchers found that instructors held two course goals, (a) teaching students how scientists do science and (b) using an interdisciplinary approach to develop students' content

knowledge of the big ideas in science. These goals were consistent with observations and with student perceptions of their experience in the course. The researchers also found an important feature of the course was its reliance on the social nature of learning. This telling case demonstrates that inquiry-based instruction is achievable in undergraduate science education and has implications for the design of college science inquiry-based instruction.

GOAL: To research K-16 science teaching and learning and contribute to the knowledge base in the field.

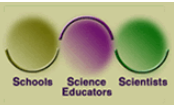
MUSEC GRADUATE STUDENTS A PRESENCE AT NARST

The National Association of Research in Science Teaching (NARST) is the largest organization of professionals committed to the improvement of science teaching and learning through research, with roughly 1800 members worldwide. NARST promotes research in science education and communication of research findings at its annual spring meeting. In 2009, the organization held

its annual meeting in Garden Grove, CA, attracting approximately 1000 attendees to participate in over 600 presentations. Sixteen MUSEC graduate students attended NARST; seven were first or co-authors on MUSEC papers presented. The MUSEC contingent continued to represent the largest graduate student group from one university at the conference.



MUSEC doctoral student Deanna Lankford presents her poster at NARST 2009.



OUTREACH

MUSEC established the Office of Science Outreach (OSO) in 2008, under the direction of Dr. Anna Waldron, to serve as a central resource at MU for science outreach. To accomplish this, the OSO works with university faculty, staff, graduate and undergraduate students, K-12 educators and students, and the general public to enhance the resources available for learning science. During the 2008-2009 academic year, the OSO collaborated on 16 MU grant proposals submitted to NSF, NIH, and the US

Department of Education. The Office hosted 6 professional development workshops: 4 for K-7 teachers in collaboration with Columbia Public Schools, and 2 for undergraduates about how to design effective outreach programs. The OSO also hosted the 2009 Missouri State Science Olympiad, which drew 2,000 students, parents, and coaches to campus. The following section highlights a number of MU outreach activities, awards, and events that demonstrate the breadth of our efforts.



MU Professor of Radiology Kattesh Katti presents at "Science Talks to You" in St. Joseph, Missouri.

SCIENCE ON THE ROAD

In collaboration with MU scientists, the OSO takes science beyond the walls of MU. In Fall 2008, MU faculty members Hannah Alexander (Biological Sciences) and Sandra Abell (MUSEC), co-instructed a *Public Understanding of Science* course for graduate students. The resulting "Science and Me" series provided presentations in lay language to increase awareness of the science behind topics such as vision, land use, and vaccines. Students delivered over

30 presentations in independent living facilities and on a popular community TV talk show. In May 2009, the OSO partnered with Dr. Bruce McClure and Vice Chancellor for Research Robert Duncan to launch a new program, "Science Talks to You," with a goal of sharing the latest scientific discoveries with communities across Missouri. "Science Talks to You" features prominent MU scientists and research relevant to Missourians' lives.

GOAL: To improve K-12 science teaching and learning.

MUSEC HELPS SELECT OUTSTANDING BIO TEACHER

Dr. Pat Friedrichsen was named Missouri 's Director for the National Association of Biology Teachers' (NABT) Outstanding Biology Teacher Award (OBTA). Pat, in conjunction with OSO staff, convened a review panel comprised of MU scientists and employees from a local company. Following much deliberation over a deserving group of science teachers, the

review panel selected Susie Helwig as the 2009 Missouri OBTA winner. Susie is an AP Biology Teacher and Science Instructional Coach from North Kansas City High School. She will represent the state of Missouri at the NABT annual conference. We salute Susie for her exceptional teaching commitment and efforts to inspire her students.



Susie Helwig, 2009 Missouri Outstanding Biology Teacher.

QUEST FOR SCIENCE-YEAR 2

MUSEC Professor Debi Hanuscin, with Dr. Delinda van Garderen (special education) received funding through the Missouri Department of Higher Education's *Improving Teacher Quality Grants Program*. QUEST: Quality Elementary Science Teaching, now in its second year, aims to improve K-6 teachers' content knowledge of physical science, use of formative assessment, and ability to support all learners through applying principles of Universal Design for Learning (UDL). A unique component of

the project is the week-long, half-day kids' QUEST program in conjunction with the teacher institute. The program provides a summer camp experience to local students, and gives teachers an opportunity to put their new knowledge and skills into practice before returning to their classrooms. In 2009, 24 teachers, mostly from the St. Louis area, and 6 pre-service teachers participated in the Teacher Institute, and about 90 local kids, ages 7-11, participated in the Student Academy.



Teacher Jewel Lane, St. Louis Public Schools, works with children in the QUEST summer program.

MU SCIENCE EDUCATOR PROVIDES PD IN TAIWAN

In October of 2008, Dr. Barrow traveled to Taiwan and facilitated professional development (PD) presentations to science educators at three major universities. He presented at the International Creativity Education Conference hosted at Sun Yat-Sen University and discussed science teacher professional development at the National Changhua University of Education. Also, he presented several topics at National Chiao Tung University, which included the

history of inquiry in the United States, teaching inquiry with the four questions strategy, clarifying misconceptions about magnets, and helping students understand shadows. Throughout his trip, Dr. Barrow collaborated with science education colleagues from around the world as well as MUSEC alums now working in Taiwan, including Candace She, Lydia Wen, and Chia-Yu Wang. Dr. Barrow also experienced many historical, cultural, and natural sites of Taiwan.

GOAL: To improve K-12 science teaching and learning.

STOM HONORS MU SCIENCE EDUCATORS

Science Teachers of Missouri (STOM) recognizes outstanding science educators for their service and commitment to improving science teaching and learning in Missouri through various awards. In 2009, the "Distinguished Service Award" recipients included Dr. Paul Germann, former MU professor of Science Education, and Dr. Miriam Golomb, MU Associate Professor

of Biological Sciences. Meera Sood, a MUSEC masters student and middle level science teacher at Smithton Middle School, received the "Outstanding Middle School Teacher Award." MU's Dr. Meera Chandrasekhar, Professor of Physics, received the "Missouri Science Educator Award" (STOM's top honor) for her career of promoting and influencing quality science education.



Professor Barrow visits MU alumnus Chia-Yu Wang in Taiwan.

PARTNERSHIP IN PLANT SCIENCE

The 2008-09 year was a busy one for PREP (Partnership for Research and Education of Plants), funded by NIH NCRR and NSF and administered by Virginia Tech, with MU as a dissemination site. Deanna Lankford, PREP coordinator and MUSEC doctoral student, brings together MU scientists and local biology teachers. She organized 3 workshops to support 23 teachers to be able to integrate student-driven plant genomics research into their biology curricula. The workshops featured presentations from

local master teachers, Carol Robertson and Christine Roberson, who shared their experiences with PREP. Participants also experienced hands-on investigations with *Arabidopsis*. They learned about designing experiments to answer research questions; organizing and interpreting data; and keeping laboratory notebooks. The participants left the workshops with specific teaching strategies and materials that will be used in their classrooms to help their students learn about plant science.



MU Biologist John Walker interacts with PREP teacher participants.

MAPS IN MEDICINE—YEAR 2

The University of Missouri program “Maps in Medicine” (PI: Folk; Co-PI Siegel) is a partnership with K-12 students and teachers in Missouri school districts – Columbia Public Schools, North Kansas City, and Normandy and Parkway School Districts in St. Louis. Maps in Medicine staff developed two interconnected modules: *Mapping Health* and *Mapping Cell Fate*. In the *Mapping Health* module, students learn the role of vectors in the transmission of avian

influenza virus and how movement of the avian vectors and spread of the virus are monitored at state, regional and global levels. In the *Mapping Cell Fate* module, students learn how cells receive instructions to maintain or change their properties, or their “fates,” and how stem cells can help cure diseases. The second summer institute was held in July, 2009 with over 20 high school biology teachers preparing to use the modules in their classrooms.

GOAL: To improve K-12 science teaching and learning.

HIGH SCHOOL STUDENTS EXPLORE LIFE SCIENCES

The third annual *Exploring Life Sciences at MU* conference, part of Life Sciences Week, was coordinated by MUSEC doctoral student, Deanna Lankford. Over 150 student participants listened to talks by researchers and examined posters about research conducted by MU graduate and undergraduate students. The high school students interacted with the researchers and learned about the

day-to-day experiences of majoring in science and participating in research at MU. PREP participants were invited to bring posters of their research to display as well. *Exploring Life Science at MU* provides a unique opportunity for collaboration among MU faculty, college student researchers, secondary science teachers, and high school students.



Maps in Medicine staff and participants.

SCIENCE TEACHER PREPARATION

MUSEC Faculty, as one of their major roles, prepare future teachers of science for early childhood, elementary, middle school, and high school science teaching. Future high school teachers of biology, chemistry, earth science, physics, or general science take the equivalent of an undergraduate science major as well as coursework in education and in science teaching and learning. Our undergraduate middle/high school science teacher preparation program graduates 15-20 new science teachers

each year, while our Master's level alternative certification program (SMAR²T) graduates another 15 per year. Our science teaching and learning courses also serve as sites for research programs about teacher learning and for graduate apprenticeships in college teaching. Graduate students serve internships in these courses under the guidance of expert faculty members, learning the philosophies and strategies for teaching future teachers.



Students in secondary methods explore teaching science with microscopes.

NEW GRANT SUPPORTS DUAL DEGREE STUDENTS

Undergraduate science students now have the option of obtaining a dual degree in a science discipline and in science teaching. Students in this new program, funded by an NSF Noyce grant, will be eligible for \$11,000 scholarships during their junior and senior years. Pat Friedrichsen, PI on the project, *Top-Notch Teachers with Dual Degrees at the University of Missouri: T2D2@ MU*, works with Co-PIs Mark Volkmann, Marcelle Siegel, John Adams, Dorina Kosztin and

Allan Whittington. This project represents a strong collaboration between science educators and science faculty in four departments. The goal of the project is to double the number of secondary science teachers graduating from MU's undergraduate teacher education program. In addition to scholarships, the project will offer science internships in informal settings during the summer to freshmen and sophomore students interested in exploring teaching as a career.

GOAL: To improve undergraduate education for science teaching majors.

HANUSCIN RECEIVES TEACHING AWARD

MUSEC faculty member Dr. Deborah Hanuscin received the 2008 Provost's Outstanding Junior Faculty Teaching Award. This award recognizes faculty for superior teaching and advising on the MU campus. Dr. H. was recognized for her teaching of future elementary teachers in the Departments of Physics & Astronomy and Learning, Teaching & Curriculum. As one of her students wrote,

"It must be difficult as a teacher to come to class every day with a smile on your face and a positive mind-set, when teaching physics to a class of students who are merely enrolled because it is a requirement. That is exactly how I would describe Dr. H.'s daily attitude in class. Her excitement for physics was infectious and had the power to motivate even the most apathetic of students."



Dr. Hanuscin receives her award from Provost Foster.

LOCAL TEACHERS AS SCIENCE TEACHER EDUCATORS

Three Columbia teachers taught science methods classes for the undergraduate program this past year. Shelli Thelen, a Columbia Public Schools (CPS) kindergarten teacher and former “Mid-Missouri Outstanding Educator,” taught the early childhood science methods course. She organized a field trip to Shelter Gardens, where early elementary students learned to classify things in nature. Julie Alexander, CPS elementary science specialist, taught the elementary science methods course for her third year. Julie,

current Elementary Director for Science Teachers of Missouri (STOM), continues to help her students build understanding of inquiry-based instruction.

Marsha Tyson, CPS 9th grade physics teacher and National Board certified, taught the second course of the secondary methods sequence. Students in these courses enjoyed the relevant classroom experiences shared by their instructors. MUSEC is fortunate to collaborate with such accomplished local science teachers.



Clayton Weidinger, SMAR²T intern, teaches physics at Jeff Junior High School in Columbia.

SMAR²T PROGRAM GRADUATES 6TH COHORT

The Science and Mathematics Academy for the Recruitment and Retention of Teachers (SMAR²T), is a post-baccalaureate teacher preparation program in science and mathematics education. All science participants enter with a bachelor’s degree in a science field, take coursework at MU, and complete an internship in a grades 6-12 science classroom; they leave with a master’s degree and teacher certification in Missouri. In summer 2008, SMAR²T

welcomed its 6th cohort of 14 science students, including both recent grads and career changers. One student, Clay Weidinger, featured in the *Missourian*, has a background in physics and nursing and a passion for education. SMAR²T has graduated 98 new science and math teachers, 85% of whom are currently teaching. With a retention rate higher than the national average, the program helps alleviate the shortage of science and mathematics teachers.

GOAL: To improve K-12 science teaching and learning.

NSTA STUDENT CHAPTER MEMBERSHIP GROWS

With more than 80 members, the MU chapter is the largest NSTA student chapter in the U.S. It includes undergraduate and graduate students majoring in science education at every level, early childhood through college. Monthly meetings include “make-and-take” science activities, an “iron scientist” competition, and an expert science teacher panel. The chapter

engaged in a successful fundraising event for the local YouZeum. Equally impressive, 8 student members, along with faculty advisor Dr. Hanuscin and graduate student advisor Aaron Sickel, presented at the national conference in New Orleans. Most members believe the chapter provides a platform for collaboration and helps develop their repertoire for science teaching.



MU NSTA members participate in a make-and-take activity at one of their monthly meetings.

COLLEGE SCIENCE TEACHING

A key strategy of MUSEC is to connect MU science educators with scientists to improve college science teaching and learning. One way we accomplish this is through our jointly appointed faculty members who teach both science and science education courses (Professors Friedrichsen, Hanuscin, and Siegel). MUSEC also sponsors, in conjunction with the Division of Biological Sciences, *Conversations about College Science Teaching*, a seminar series devoted to sharing best practices. We offered eight

Conversations in 2008-2009, by MU science and science education faculty and visitors. The “College Science Teaching” course (taught by Drs. Abell and Siegel) focuses on the preparation of future college science instructors. Also, each fall Dr. Abell visits Dr. Kathy Newton’s survival skills course for new biology graduate students to discuss science teaching opportunities at MU. This section highlights MUSEC projects that focus on the improvement of college science education.



Future faculty participants in the summer, 2008 CUES workshop.

THE MINI-JOURNAL: AN INQUIRY-BASED APPROACH

The mini-journal is an approach to laboratory instruction that replaces cookbook labs with activities more closely resembling scientific inquiry. Funded by the NSF, the CUES project (Connecting undergraduates to the Enterprise of Science) (PI Frank Schmidt; CO-PIs Abell, Weaver, and Adams; and GRA Witzig) attempts to help science faculty integrate the mini-journal approach into their own teaching. Last year, CUES held its second institute with 28 new faculty and future

faculty along with 9 returning participants who served as mentors. Participants came from different institution types, taught in various science disciplines, and worked with students at the introductory level through senior capstone courses. The CUES team’s article describing the mini-journal model, soon to appear in the *Journal of College Science Teaching*, will reach a broader audience of college science faculty to assist them in adapting their laboratories to include more inquiry.

GOAL: To improve undergraduate education for science majors and non- majors.

EDUCATING UNDERGRADS ABOUT STEM CELLS

Chris Pierret, a former doctoral student in biological sciences, under the mentorship of Dr. Friedrichsen, designed and co-taught a course called “Stem Cells and Society” in May 2007. This course aimed to help students explore the biology of stem cell research and the controversies surrounding it. Pierret’s biology dissertation included a chapter about student responses to the course.

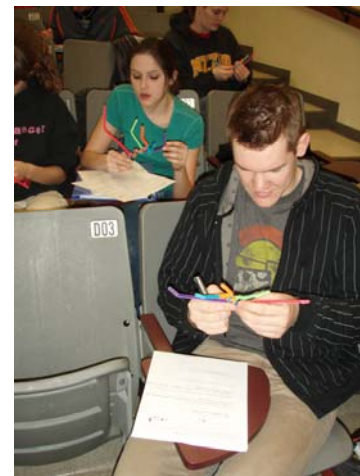
This year, Pierret and Friedrichsen published a paper explaining the nature of the course in *CBE: Life Sciences Education* journal. The article provides in-depth descriptions of the content, instructional activities, and assessment practices that were used in the course, as well as insights into teaching science content that is often deemed controversial.



RETHINKING INTRODUCTORY PHYSICS

Rethinking Directions in Undergraduate Curriculum Experience (ReDUCE) is a collaborative project between Professor Hanuscin and Physics faculty members Carlos Wexler and Haskell Taub. The focus of the collaboration is modifying and re-aligning curriculum, instruction, and assessment in introductory physics courses for non-majors. Rather than the familiar mile-wide and inch-deep course content, “ReDUCEd” curricula will focus on understanding fewer concepts more deeply. Student learning is promoted

through the use of reform-based teaching strategies including formative assessment, inquiry-based instruction, and just-in-time teaching. An initial pilot study, funded through an Interdisciplinary Planning Grant from the Department of Learning, Teaching, and Curriculum, focused on revising the laboratory component of the course. The group currently has a proposal under review in the NSF CCLI program to expand efforts into lecture and recitation sections.



Students in BioSci 3210 use a pipe cleaner model to understand phylogenetic trees.

RESEARCH INFORMS BIOLOGY TEACHING

Kristy Halverson, a MUSEC doctoral student, knows how to use research to inform teaching. Kristy collaborated with Drs. Abell, Friedrichsen, and Pires (Biological Sciences) to revise *Plant Systematics* (BioSc 3210). In her dissertation research, Kristy identified common challenges undergraduates encountered when interpreting evolutionary trees. To help overcome these challenges, she designed a pipe cleaner manipulative that allowed

students to interact with a moveable 3D model as they thought about the evolutionary relationships represented. Students provided positive feedback regarding the effectiveness of the pipe cleaner activity. “I had trouble imagining the ‘rotation’ of the branches in my head, and this [model] provided a physical rotation that I could see.” Kristy is writing an article for the *American Biology Teacher* about the pipe cleaner tree activity.

GOAL: To improve undergraduate education for science majors and non-majors.

WARM LITTLE POND

For years Drs. Schmidt and Weaver have taken students in their honors science course, *Warm Little Pond*, outside to measure a pond on the MU campus. The activity creates a mindset that science involves multiple ways of solving problems, and that the “right answer” is confirmed by evidence, not by a textbook. In measuring the pond, students have to make many decisions. In discussing their

measurements, they learn firsthand why significant digits are important and how modeling aids understanding. An article describing the pond activity and student responses, written by former MUSEC doctoral student Kadir Demir and Drs. Abell and Schmidt, will soon appear in the *Journal of College Science Teaching*, informing other science instructors how to help students think scientifically.



Students measure a pond on the MU camps for their first lab in Warm Little Pond.

GRADUATE EDUCATION

Science Education graduate programs continue to be strong. In 2008-2009, 18 doctoral students and 3 masters students were in residence, most supported by teaching and research assistantships. Two students completed their doctoral dissertations this calendar year. Science education doctoral students are actively engaged in research, teaching, and outreach projects. MUSEC graduate students and former graduate students were named 32 times as authors/co-authors of papers presented at

professional conferences in 2008-2009, and were co-authors on 16 published papers. In 2009, MUSEC supported 16 students to attend and present at NARST, the largest meeting of science education researchers worldwide. Science Education graduate programs require a significant amount of science content coursework. Doctoral research projects often rely on strong collaborations with faculty members in the sciences and every doctoral committee includes a scientist as a member.



New MUSEC doctoral students interact with the veterans at NARST 2009.

MUSEC WELCOMES NEW DOCTORAL STUDENTS

MUSEC welcomed six new doctoral students in 2008-2009. Aaron Sickel, Dannah Schaffer, and Heather Worsham came to MU as former high school teachers with Master's degrees in science education (Heather is a graduate of MU's SMAR²T program). Deepika Menon, Will Romine, and Emily Walter received their Master's degrees in science disciplines (physics, geology, and

biology) and are interested in the improvement of college science teaching. These students look forward to their involvement with science education research. This past year, MUSEC also hosted a visiting doctoral student from Turkey, Sinan Ozgelen. Sinan received extensive mentoring from Dr. Hanuscin about analyzing data for his dissertation on the nature of science.

GOAL: To help prepare graduate students to be active participants in continuing the reform of K-16 science education.

NATIONAL SCIENCE ED SCHOLARS VISIT MUSEC

MUSEC invited two accomplished science education scholars to present their research at MU in 2008-2009. Dr. Loretta Jones, professor of chemistry and biochemistry at the University of Northern Colorado, presented her research on visualizations in chemistry learning at the *Conversations about College Teaching* series. She discussed the challenges and advantages of animations in helping students understand chemistry concepts. Dr. Gail Jones, professor of science

education at North Carolina State University, presented her research on students' conceptual difficulties in understanding the scale of different scientific phenomena to the Department of Biochemistry and at the *Mathematics and Science Education Research Colloquium*. Her presentations described common misconceptions students have about the relative size of objects and organisms and implications for science curriculum reform.



M. Gail Jones, North Carolina State University



Loretta Jones, University of Northern Colorado

STUDENTS INVESTIGATE CLASSROOM DISCOURSE

Six students enrolled in an advanced doctoral level seminar course titled “Discourse in Science Education,” taught by Dr. Abell in Fall, 2008. The purpose of the course was to read, discuss, and understand research regarding the ways in which teachers and students talk about science in the classroom. As the course progressed, three students became inspired to design a research project to study the discourse in a biology course for non-majors at MU. Under Abell’s direction, Aaron Sickel, Binaben

Vanmali, and Stephen Witzig designed lessons using the 5E instructional model for BioSci 1010, a large enrollment course. They examined the discourse that ensued during small and large group interactions in the course to understand what happened during the different phases of instruction. Their research, which they plan to present at NARST, will help college science educators design reform-oriented lessons and guide the use of effective science talk in large enrollment courses.



Andrew West



Kristy Halverson

MUSEC GRADUATE STUDENTS RECEIVE AWARDS

Each year, MUSEC hosts the Southwestern Bell Science Education Awards ceremony which honors two doctoral students for their achievement in teaching and research. Andrew West received the Graduate Teaching Assistant of the Year Award for his efforts in educating preservice teachers, supervising teacher interns, and serving as a cognitive coach for inservice physics teachers. “Andrew’s ability to help others through careful listening and penetrating

questions is the essence of his expertise as a science teacher educator.” Kristy Halverson received the Graduate Research Assistant of the Year Award. She collaborated with colleagues on several research projects, and carved out a niche with her dissertation research on college students’ thinking with biological representations. She mentored undergraduate and graduate student researchers, and is “bright, thoughtful, and a true pleasure to work with.”

GOAL: To help prepare graduate students to be active participants in continuing the reform of K-16 science education.

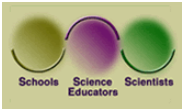
MOTHER/DAUGHTER GRADUATE STUDENT DUO

Linda Lacy, a doctoral student in the MU science education program and former middle school science teacher, is Elementary Science Coordinator for the North Kansas City School District and President Elect of STOM. Throughout her career, she has worked tirelessly to improve science teaching and learning in Missouri K-12 classrooms. In Fall 2008, her daughter Jennifer began the MU

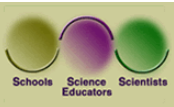
science education master’s program. She entered the program with two years experience as a high school physical science teacher. Upon graduation, Jennifer plans to return to science teaching and apply what she has learned. One day she hopes to pursue a Ph.D. in educational philosophy. This mother-daughter team of passionate science educators is an asset to MUSEC.



MUSEC graduate student duo, Linda and Jennifer Lacy.



Appendix A
Faculty Bios



Sandra K. Abell, Curators' Professor

Research Focus: Science Teacher Learning

My research program examines science teaching and learning, K-20. In particular, we study how teachers learn to teach science and how they improve their instruction over time. In the past, we have applied the theoretical framework of conceptual change to teacher learning, studying how future teachers of elementary school science learn science content, form conceptions of the nature of science, and develop their theories of science teaching and learning. We also explored how practicing middle level teachers respond to innovations in teaching science in professional development settings. At the college level, we examined how science faculty reflect upon and change their teaching practice through approaches that involve them as researchers in their own classrooms.

Current projects apply a teacher knowledge framework to understanding science teacher development. In one project, we work with individuals who have decided to become middle and secondary science teachers later in their professional lives following careers in science related fields. In particular, we are interested in how they develop knowledge for teaching and how their identities as scientists influence their development throughout the teacher preparation program. In a second project, we are studying how college science instructors go about changing their practice to incorporate inquiry-based teaching strategies into laboratory instruction.

For a list of my current projects, see <http://www.coe.missouri.edu/~abells/>

Recent Publications

Abell, S. K., & Lederman, N. G. (Eds.). (2007). *Handbook of research on science education*. Mahwah, NJ: Lawrence Erlbaum.

Abell, S. K., Lannin, J. K., Marra, R. M., Ehlert, M. W., Cole, J. S., Lee, M. H., Park Rogers, M.A., & Wang, C.-Y. (2007). Multi-site evaluation of science and mathematics teacher professional development programs: The project profile approach. *Studies in Educational Evaluation*, 33, 135-158.

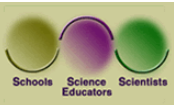
Park Rogers, M. A., & Abell, S. K. (2008). The design, enactment, and experience of inquiry-based instruction in undergraduate science education: A case study. *Science Education*, 92, 591-607.

Abell, S. K. (2008). PCK twenty years later: Does it remain a useful idea? *International Journal of Science Education* (special issue on PCK), 30, 1405-1416.

Abell, S. K., Park Rogers, M. A., Hanuscin, D., Gagnon, M. J., & Lee, M. H. (2009). Preparing the next generation of science teacher educators: A model for developing PCK for teaching science teachers. *Journal of Science Teacher Education*, 20, 77-93



**Professor
Sandra K.
Abell**



Lloyd H. Barrow, Professor

Research Focus: Elementary Science Education

My research focuses on ways to improve K-6 science instruction. Specifically, this has involved an analysis of curriculum (e.g., concepts associated with “shadows” in preservice elementary science methods textbooks). I also continue my interest in inquiry and research productivity.

In addition, my research examines the employment opportunities of various teacher education specialties. This includes a longitudinal analysis of science education positions in higher education. My faculty productivity research focuses on science educators. I plan to replicate the 1990s study in the coming year.

In 2009 I was honored to receive the Outstanding Mentor Award from the Association for Science Teacher Education.

Recent Publications

Odom, A., & Barrow, L. (2007). High school biology students' knowledge and confidence for diffusion and osmosis concepts. *School Science & Mathematics, 107*, 94-101.

Barrow, L. (2007) Bringing light onto shadows. *Science and Children, 44*(9), 43-5.

Decker, T., Summers, G., & Barrow, L. (2007) The treatment of geologic time and history of life on Earth in high school biology textbooks. *American Biology Teacher, 69*, 401-5.

Barrow, L. (2008) Facilitating designs for inquiry with the four questions strategy. *Science Activities, 45*(1), 9 - 11.

Barrow, L., Settlage, J., & Germann, P. (2008). Institutional research productivity in science education for the 1990s: The top 30 ranking. *Journal of Science Education and Technology, 17*, 357-365.

Barrow, L., Wissehr, C., & Ratley, C. (2008). Science notebooks facilitate weather literacy. *The Earth Scientist, XXVIII*(3), 20-23.

Barrow, L. (2009). [Review of the book *Science Safety in the Community College*]. *School Science and Mathematics, 109*, 212.

Concannon, J., & Barrow, L. (2009). A cross sectional study of engineering students' self-efficacy by gender, ethnicity, and transfer students. *Journal of Science Education and Technology, 18*, 163-172.



**Professor
Lloyd H.
Barrow**

Patricia Friedrichsen, Associate Professor

Research Focus: Science Teacher Learning; Biology Education



My research focuses on science teacher learning at the secondary and college levels. In teacher learning studies, I use the conceptual framework of pedagogical content knowledge (PCK) which outlines a specialized knowledge base for teaching. I am particularly interested in the science teaching orientation component, examining how teachers' beliefs influence their teaching practice. In the past I've studied science teaching orientations of experienced biology teachers. In a current project, we are studying teachers' PCK development in a post-baccalaureate alternative certification program (ACP). In a recent study with Patrick Brown and Sandra Abell, we examined the development of pre-service biology teachers' teaching orientations. We found the teachers' beliefs focused on "teaching as telling, learning as listening" and these strongly-held beliefs filtered what the teachers learned in the ACP. In a current study with Deanna Lankford, we are examining experienced biology teachers' PCK for teaching osmosis and diffusion. The findings of this study will have practical applications for pre-service and in-service teacher education.

At the post-secondary level, I collaborated with a biology graduate student, Chris Pierret, to design a new course, *Stem Cells & Society*. To facilitate Chris's learning about teaching, we designed an action research project in which we examined the effectiveness of innovative instructional strategies used in the course. In a related study, I worked with Kristen Hutchins as she studied college science teachers as they learned about inquiry teaching in a professional development program. The findings from these two studies have implications for graduate education and faculty development.

For a list of my current projects, see <http://www.coe.missouri.edu/~friedrichsenp/>

Recent Publications

Friedrichsen, P., Chval, K., & Teuscher, D. (2007). Strategies and sources of support for beginning teachers of science and mathematics. *School Science and Mathematics*, 107(5), 169-181.

Friedrichsen, P., Lannin, J., Abell, S., Arbaugh, F., & Volkmann, J. (2008). Examining incoming identities in an alternative certification program for mathematics and science. *Eurasia Journal of Mathematics, Science and Technology Education*, 4(2), 175-188.

Brown, P., Friedrichsen, P., & Mongler, B. (2008). 2-Liter bottles and botanical gardens: Using inquiry to learn ecology! *Science Activities*, 44(4), 153-157.

Pierret, C., & Friedrichsen, P. (2009). Stem cells and society: An undergraduate course exploring the intersections among science, religion, and law. *CBE: Life Sciences Education*, 8(1), 79-87.

Friedrichsen, P., Abell, S., Pareja, E., Brown, P., Lankford, D., & Volkmann, M. (2009). Does teaching experience matter? Examining biology teachers' prior knowledge for teaching in an alternative certification program. *Journal of Research in Science Teaching*, 46(4), 357-383.

Professor
Patricia
Friedrichsen

Deborah L. Hanuscin, Assistant Professor

Research Focus: Science Teacher Learning; Nature of Science



My research program examines the epistemological dimensions of science teaching and learning, K-20. In particular, I study how teachers come to understand the nature of science and how their epistemological beliefs about science impact the way science is portrayed in their classrooms. In the past, I have applied the theoretical framework of conceptual change to teacher learning about the nature of science across their program of study, both in their science content courses and education coursework. I have also explored how practicing elementary teachers respond to innovations in teaching the nature of science and inquiry in professional development settings. At the college level, I have examined how faculty and teaching assistants' views of the nature of science and their learning to teach about the nature of science in laboratory settings.

Current projects apply a pedagogical content knowledge (PCK) framework to understanding science teacher development and the effective teaching of the nature of science in elementary classrooms. In one project, we are examining the practices of elementary teachers who have successfully improved their students' views of the nature of science. In particular, we are interested in how they develop knowledge for teaching the nature of science and how teacher educators can support prospective teachers in developing their pedagogical content knowledge for teaching the nature of science. In another project, a self-study, I am collaborating with science faculty to better understand how our PCK for teaching about the nature of science guides our instruction in college science courses.

For a list of my current projects, see <http://www.missouri.edu/~hanuscind/>

Recent Publications

Akerson, V.L., & Hanuscin, D. (2007). Teaching the nature of science through inquiry: Results of a three-year professional development program. *Journal of Research in Science Teaching*, 44(5), 653-680.

Hanuscin, D. (2007). The use of specialized laboratory facilities for science in elementary schools: A call for research. *Journal of Elementary Science Education*, 19(2), 59-64.

Hanuscin, D., & Lee, M. H. (2008). Using the learning cycle as a model for teaching the learning cycle to preservice elementary teachers. *Journal of Elementary Science Education*, 20(2), 51-66.

Tucker, S. A., Hanuscin, D., & Bearnes, C. J. (2008). Igniting girls' interest in chemistry. *Science*, 319(5870), 1621-1622.

Varma, T., & Hanuscin, D. (2008) Pre-service elementary teachers' field experiences in classrooms led by science specialists. *Journal of Science Teacher Education*, 19(6).

Abell, S. K., Rogers, M. P., Hanuscin, D. L., Lee, M. H., & Gagnon, M. J. (2009). Preparing the next generation of science teacher educators: A model for developing PCK for teaching science teachers. *Journal of Science Teacher Education*, 20(7), 77-93.

**Professor
Deborah L.
Hanuscin**

Marcelle A. Siegel, Assistant Professor

Research Focus: Decision Making; Assessment



Our research approach to problems in science education is based in cognitive theory (the science of individual learning) and sociocultural approaches (the theory of culture and social interaction as they affect development and learning). We focus on science, health, and environmental learning and teaching in middle school, high school, and college. Currently, we have two goals for science education research: 1) to examine cognitive decision making processes, and 2) to study classroom assessment practices and develop resources for teachers to improve assessment practices.

We aim to develop theoretical models of students' scientific decision making and teachers' instructional decision making. Decision making is an essential goal of the National Science Education Standards, yet is rarely learned in science classrooms. Prior work has identified ways of supporting decision making in class and studied the effects of different instructional materials. Research with teachers has refined methods for making teachers' thinking processes visible through the discussion of student work. Currently, we are studying undergraduates' decision making about biotechnology and ethical issues.

Assessments have a large impact on what is learned in a classroom. Assessment practices that support, foster, and monitor learning are essential to an effective classroom. Our work has refined and studied the effects of assessments in middle school life science, with a focus on creating more equitable assessments for English language learners. We are also studying preservice teachers' views of assessment to clarify how understanding develops.

For a list of my current projects, see: <http://web.missouri.edu/~siegelm/>

Recent Publications

Fong, S.R., & Siegel, M.A. (2005). Teaching well: Science teachers' investigation and use of student sociocultural background. In D.M. McInerney & S. van Etten (Eds.) *Research on Sociocultural Influences on Motivation and Learning, Vol. 5, Focus on Teaching* (pp. 101-128). Greenwich, CT: Information Age Publishing.

Siegel, M.A. (2006). High school students' decision making about sustainability. *Environmental Education Research, 12*(2), 201-215.

Siegel, M.A. (2007). Striving for equitable classroom assessments for linguistic minorities: Strategies for and effects of revising life science items. *Journal of Research in Science Teaching, 44*(6), 864-881.

Siegel, M.A., Wissehr, C. F., & Halverson, K. L. (2008). Sounds like "success:" A framework for equitable assessment. *The Science Teacher, 75*(3), 43-46.

Halverson, K. L., Siegel, M. A., & Freyermuth, S. K. (2009). Lenses for framing decisions: Undergraduates' decision making about stem cell research. *International Journal of Science Education, 31*, 1249-1268.

**Professor
Marcelle A.
Siegel**

Mark J. Volkmann, Associate Professor

Research Focus: Science Teacher Learning



My research program focuses on learning to teach science. In the past I have studied teaching science through inquiry. I investigated my own learning as I taught physics to undergraduate elementary education majors. I studied how a graduate student learned to teach physics through inquiry and how undergraduates learned physics concepts through inquiry. I used qualitative methods to understand how individuals made sense of teaching and learning in terms of their orientations to teaching and their professional identities as science teachers. Currently, I am working with a team of researchers in science and mathematics education to investigate teacher development. We use the conceptual framework of pedagogical content knowledge to study beginning teachers. Specifically, we are interested in finding out what knowledge teachers bring to science classrooms, what they know about student learning, how they use that knowledge to plan and implement instruction, and what knowledge they have about goals and sequence of instruction.

This fall (2009) I begin a new project. With funding from the National Science Foundation, we will develop a proposal to the Robert Noyce Master Teacher Program. The purpose of this program is to develop teacher leaders in science education who have a deep understanding of student learning and science instruction, assessment, and curriculum and have the ability to use that knowledge to mentor interns and beginning teachers. This project will continue my work in the Physics First project where I investigated how a professional development strategy – lesson study – supports teacher learning at mid-career.

For a list of my current projects, see: <http://www.missouri.edu/~volkmanmj/>

Recent Publications

Arbaugh, F., Abell, S., Lannin, J., Volkmann, M., & Boone, W. (2007). Field-based internship models for alternative certification of science and mathematics teachers: Views of interns, mentors, and university educators. *Eurasia Journal of Mathematics, Science & Technology Education*, 3(3), 191-201.

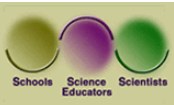
Friedrichsen, P.M., Lannin, J.E., Abell, S. K., Arbaugh, E. F., & Volkmann, M. J. (2008). Examining incoming identities in an alternative certification program in mathematics and science. *Eurasia Journal of Mathematics, Science & Technology Education*, 4(2), 175-188.

Varma, T., Volkmann, M. J., & Hanuscin, D. (2009). Preservice elementary teachers' perceptions of their understanding of inquiry and inquiry-based science pedagogy: Influence of elementary science education methods course and science field experience. *Journal of Elementary Science Education*.

Friedrichsen, P., Abell, S., Pareja, E., Brown, P., Lankford, D., & Volkmann, M. J. (2009). Does teaching experience matter? Examining biology teachers' prior knowledge for teaching in an alternative certification program. *Journal of Research in Science Teaching*, 46, 357-383.

Boone, W. J., Abell, S. K., Volkmann, M. J., Arbaugh, F., & Lannin, J. K. (in press). The development and administration of a standards-based instrument to evaluate the perceived preparedness of science and mathematics teachers in an alternative certification program. *International Journal of Science and Mathematics Education*.

**Professor
Mark J.
Volkmann**



Anna M. Waldron, Assistant Professor of Practice

Research Focus: Science Outreach

As Director of the Office of Science Outreach, my mission is to engage university students, scientists, K-12 teachers and students, and the public in meaningful dialogue to improve science teaching and learning through university outreach. Science outreach has many definitions, and my goal is to increase understanding of science through creation of effective programs that facilitate collaboration among university scientists, schools, and other community organizations. Effective outreach requires planning partnerships that directly benefit all those involved. We work to involve people in program design, development, implementation and evaluation to achieve the most effective outreach program outcomes possible.

The Office of Science Outreach (OSO) started a new program this year to raise awareness of MU science research across the state. *Science Talks to You* expands the popular *Saturday Morning Science* lecture series to a statewide audience. In May 2009, we hosted our first event in St. Joseph and Maryville, Missouri, impacting over 200 community members. During this program, we gathered data to include in a proposal to expand the program to multiple communities across the state. In addition to actively creating programs, my research interests include how young women become engaged in science and technology and how the public comes to a meaningful understanding of science, technology, engineering and math.

In 2009-2010, OSO collaborated on the development of grant proposals with MU scientists totaling over \$7million.

For a list of current OSO projects, see scienceoutreach.missouri.edu.

Recent publications

Waldron, A.M., Batt, C.A., Spencer, D. (2006). Too Small to See: Public Understanding of Nanotechnology. *Journal of Nanoparticle Research*, 8, 569-575.

Batt, C.A., Waldron, A.M., Broadwater, N. (2008). Numbers, Scale and Symbols: The Public Understanding of Nanotechnology. *Journal of Nanoparticle Research*, 10, 1141-1148.



**Professor
Anna M.
Waldron**



**Appendix B
2008-2009
MUSEC
Publications**

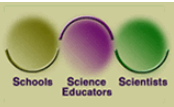


Papers in Research Journals

- Abell, S. K. (2008). PCK twenty years later: Does it remain a useful idea? *International Journal of Science Education* (Special issue on PCK), 30, 1405-1416.
- Abell, S. K., Rogers, M. P., Hanuscin, D. L., Lee, M. H., & Gagnon, M. J. (2009). Preparing the next generation of science teacher educators: A model for developing PCK for teaching science teachers. *Journal of Science Teacher Education*, 20(9), 77-93.
- Barrow, L. (2009). [Review of the book *Science Safety in the Community College*]. *School Science and Mathematics*, 109, 212.
- Barrow, L., Settlage, J., & German, P. (2008). Institutional research productivity in science education for the 1990s: Top 30 rankings. *Journal of Science Education and Technology*, 17, 357-365.
- Concannon, J., & Barrow, L. (2009). A cross sectional study of engineering students' self-efficacy by gender, ethnicity, and transfer students. *Journal of Science Education and Technology*, 18, 163-172.
- Friedrichsen, P., Abell, S., Pareja, E., Brown, P., Lankford, D., & Volkmann, M. (2009). Does teaching experience matter? Examining biology teachers' prior knowledge for teaching in an alternative certification program. *Journal of Research in Science Teaching*, 46, 357-383.
- Halverson, K., Siegel, M.A., & Freyermuth, S. (2009). Lenses for framing decisions: Undergraduates' decision making about stem cell research. *International Journal of Science Education*, 31, 1249-1268.
- Park Rogers, M. A., & Abell, S. K. (2008). The design, enactment, and experience of inquiry-based instruction in undergraduate science education: A case study. *Science Education*, 92, 591-607.
- Pierret, C., & Friedrichsen, P. (2009). Stem cells and society: An undergraduate course exploring the intersections among science, religion, and law. *CBE: Life Sciences Education*, 8(1), 79-87.
- Varma, T., Volkmann, M. J., & Hanuscin, D. (in press). Preservice elementary teachers' perceptions of their understanding of inquiry and inquiry-based science pedagogy: Influence of elementary science education methods course and science field experience. *Journal of Elementary Science Education*.
- Witzig, S. B., Zhao, N., Abell, S. K., Weaver, J. C., Adams, J. E., & Schmidt, F. J. (in press). Achievable inquiry in the college laboratory: The mini-journal. *Journal of College Science Teaching*.

Papers in Practitioner Journals

- Abell, S. K. (2008). Children's literature and the science classroom. (Perspectives Column). *Science and Children*. 46(3), 54-55.
- Abell, S. K. (2009). Thinking about thinking in science class. (Perspectives Column). *Science and Children*, 46(6), 56-57.
- Barrow, L. (2008) Facilitating designs for inquiry with the four questions strategy. *Science Activities*, 45(1), 9 - 11.
- Barrow, L., Wissehr, C., & Ratley, C. (2008). Science notebooks facilitate weather literacy. *The Earth Scientist*, XXVIII(3), 20-23.
- Brown, P. L., & Abell, S. K. (2009). Societal issues in science. (Perspectives Column). *Science and Children*, 46(8), 64-65.
- Gagnon, M. J., & Abell, S. K. (2009). ELLs and the language of school science. (Perspectives Column). *Science and Children*, 46(5), 50-51.
- Halverson, K. L. & Lankford, D. M. (in press). Science galls me: What is a niche anyway? *American Biology Teacher*.
- Hanuscin, D. & Lee, E. J. (2009). Helping students understand the nature of science. (Perspectives Column). *Science & Children*, 46(7), 56-57.
- Lee, M. H., & Hanuscin, D. L. (2008). A (mis)understanding of astronomical proportions? (Perspectives Column). *Science and Children*, 46(1), 60-61.
- Park Rogers, M., A., & Abell, S. K. (2008). The art (and science) of teacher questioning. (Perspectives Column). *Science and Children*. 46(2), 54-55.



- Robertson, C. & Lankford, D.M. (in press). Laboratory notebooks prepare students for authentic science, *The Science Teacher*.
- Smith, S. R., & Abell, S. K. (2008). Using analogies in elementary science. (Perspectives Column). *Science and Children*, 46(4), 50-51.
- Vanmali, B., & Abell, S. K., (2009). Finding a place for girls in science. (Perspectives Column). *Science and Children*, 46(9), 62-63.

Book Chapters

- Fraser-Abder, P., Abell, S. K., & Trumbull, D. J. (2009). Models of secondary science teacher preparation. In A. Collins & N. Gillespie, (Eds.). *The continuum of secondary science teacher preparation: Knowledge, questions and research recommendations* (pp. 23-32). Rotterdam, The Netherlands: Sense Publishers.
- Plummer, D., & Barrow, L. (2009). Line graphing skills and attitudes of college biology non-majors. In I. Saleh & M. Khine (Eds), *Fostering scientific habits of mind: Pedagogical knowledge and best practices in science education* (pp. 235-260). Boston: Sense Publishers.

Dissertation Completed

- Patrick L. Brown. (2008, August). Investigating science teacher knowledge of learners and sequence of instruction in an alternative certification program. Doctoral Dissertation, Science Education, University of Missouri (Advisors: Abell and Friedrichsen; Position: Washington University in St. Louis).
- Concannon, J. (2008, August). A cross-sectional study of engineering majors' self-efficacy. Doctoral Dissertation, Science Education, University of Missouri. (Advisor: Barrow; Position: Westminster College).

Refereed Papers at Professional Meetings

American Educational Research Association, April 2009, San Diego, CA

- Brown, P., Friedrichsen, P., & Abell, S. *Teachers' knowledge of learners and instructional sequencing in an alternative certification program.*
- Marra, R., Abell, S., Ehlert, M., Lannin, J., Park-Rogers, M., Smith, S., Merle, D., & Arbaugh, F. *Orientations to professional development design and implementation: Understanding their relationship to PD outcomes across multiple projects.*
- Siegel, M.A., & Wissehr, C. *Assessment of all learners: Developing expertise in equitable assessment with preservice teachers.*
- Tsai, I., Laffey, J., & Hanuscin, D. *Effectiveness of an online community of practice for learning to teach elementary science.*
- Tsai, I., Laffey, J., & Hanuscin, D. *Understanding the social nature of an online community of practice for learning to teach.*

Association for Science Teacher Education, January, 2009, Hartford, CT

- Barrow, L. *Strategies rather than tricks for securing a faculty position.*
- McDonald, J. T., & Lee, M. H. *Beyond the solar system: Assessing and understanding students' ideas about the universe and assessing teachers' knowledge of learners.*

National Science Teachers Association (National), March, 2009, New Orleans, LA

- Barrow, L. *Growing seeds to implement inquiry and teaching standards.*
- Hanuscin, D., Sickel, A., Lonsway, K., Lonergan, Weber, M., K., Roe, J., Johnson, J., Strackeljahn, A., & Murphy, K. *De-cookbook science activities: A recipe for success.*
- Hanuscin, D., Weaver, J. C., Manteuffel, M. S., Witzig, S., & Veverka, L. M. *Connecting undergraduates to the enterprise of science through inquiry.*
- Lee, M. H., & Donna, J. *What research says to the science teacher about effective professional development.*



Refereed Papers at Professional Meetings (cont.)

National Association of Biology Teachers, October, 2008, Memphis, TN

Lankford, D. M. & Halverson, K. L. *Five steps: Developing problem based learning lessons to investigate biology concepts.*

Halverson, K. L. *Using hypothetical flowering plants to develop fundamental phylogenetic tree-reading and tree-building skills.*

Halverson, K.L., Siegel, M.A., Freyermuth, S.K., & Clark, C. *What do undergraduates misunderstand about stem-cell research?*

Rushin, J. W., Meyers, J. L., Ottinger, M & Ellis, J. *Inquiry teaching in the middle schools through a university-school district partnership.*

Witzig, S.B. *From cookbooks to inquiry: A case-study on achievable inquiry in an upper-level biochemistry course.*

National Association for Research in Science Teaching, April, 2009, Garden Grove, CA

Abell, S., Anderson, C., Kahle, J. B., Barton, A. C., Champagne, A., Gilmer, P. J., Holliday, W. G., Krajcik, J., Luft, J., Moore, F., Rennie, L., & Zeidler, D. *NARST's grand challenges and great opportunities: Presidential speech reaction panel.*

Barrow, L., & Tang, N. *Up and down rankings in science education institutional research productivity.*

Boone, W. J., Abell, S. K., Volkmann, M. J., Arbaugh, E. F., & Lannin, J. K. *The development and utilization of a standards-based instrument to evaluate the perceived preparedness of science and mathematics teachers in an alternative certification program.*

Brown, P. L., Friedrichsen, P., & Abell, S. (2009, April). *Investigating the development of science teaching orientations during an alternative certification program.* National Association for Research in Science Teaching, Garden Grove, CA.

Cho, M.H., Lankford, D.M., & Wescott, D. *Effects of problem based learning on students' learning satisfaction, motivation, and conceptual change in a college biology course.*

Concannon, J., Siegel, M.A., Halverson, K., & Freyermuth, S. *College students' preconceptions of stem cells, stem cell research, and cloning.*

Gess-Newsome, J., Schwartz, R., Hanuscin, D., Olson, J., Smith, D., Pasquale, M., & Levy, A. *The importance of elementary science education in the NCLB era.* (Panel).

Halverson, K., Abell, S., Friedrichsen, P., & Pires, J. C. *Testing a model of representational competence applied to phylogenetic tree thinking.*

Hanuscin, D., & Hian, J. *Developing pedagogical content knowledge for teaching the nature of science: lessons from a mentor-mentee relationship.*

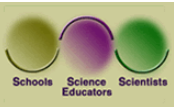
Musikul, K., & Abell, S. K. *Professional development for elementary teachers of science in Thailand: A holistic examination.*

Romine, W.L., Siegel, M.A., & Roberts, T.M. *Identification and analysis of science teachers' preconceptions related to avian influenza.*

Volkmann, M. J., Brown, P., West, A., Lankford, D., & Abell, S. *Changes in beginning secondary science teachers' PCK for instruction.*

Wang, C., & Barrow, L. *Characteristics and levels of sophistication about mental modeling ability: A preliminary study on general chemistry students' thinking processes with mental models of molecular geometry and polarity.*

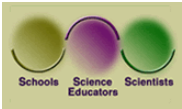
Witzig, S. B., Abell, S. K., & Schmidt, F. J. *It doesn't really matter what the right answer is: A case-study on implementing inquiry-based laboratories at the university level.*



Refereed Papers at Professional Meetings (cont.)

Other National and International Professional Meetings

- Abell, S. K. (2009, February). *Best practices in elementary science teacher preparation*. American Association of Physics Teachers: Chicago, IL.
- Barrow, L. (2008, October). *Encouraging children's creativity with scientific inquiry*. International Creativity in Education Conference: Kioshung, Taiwan.
- Barrow, L. (2008, October). *The overlooked dropouts – science*. Science Education at the Crossroads Conference: Salt Lake City, UT.
- Barrow, L. (2008, November). *Constructing understanding about shadows*. School Science and Mathematics Association: Raleigh, North Carolina.
- Concannon, J. & Barrow, L. (2008, June). *A cross-sectional study of engineering self-efficacy*. American Society for Engineering Education: Philadelphia, PA.
- Harman, P., Bailey, J., Reinfeld, E., Dussault, M., & Lee, M. (2009, June). *Exploring beyond the solar system in the international year of astronomy*. Astronomical Society of the Pacific: St. Louis, MO.
- Halverson, K. L., Pires, J. C., & Abell, S. K. (2008, June). *"Tree thinking" issues: Undergraduates' reasoning about phylogenies*. Society for the Study of Evolution: Minneapolis, MN.
- Hanuscin, D., Speck, A., & Ruzhitskaya, L. (2009, February). *What do students in an introductory astronomy course believe science is?* American Association of Physics Teachers: Chicago, IL.
- Merle-Johnson, D., & Abell, S.K. (2008, October). *College students' understanding of geological concepts: Earth structure and processes*. Joint Meeting of The Geological Society of America, Soil Science Society of America, American Society of Agronomy, Crop Science Society of America, Gulf Coast Association of Geological Societies with the Gulf Coast Section of SEPM: Houston, TX.
- Wexler, C., Hanuscin, D., Mower, M., & Taub H. (2009, March). *ReDUCE: Rethinking Directions in Undergraduate Curriculum Experiences*. American Physical Society: Pittsburgh, PA.



**Appendix C
2008-2009
MUSEC Grants**

www.musec.missouri.edu

MU Science Education Center
303 Townsend Hall
University of Missouri
Columbia, MO 65211-2400
Phone: 573-884-1401
Fax: 573-884-2917
E-mail: estesma@missouri.edu



The MU Science Education Center is dedicated to the improvement of science teaching and learning, K-20, and to the concomitant generation and communication of knowledge about science teaching and learning. The Center accomplishes its mission through the active collaboration among scientists, science educators, and school-based colleagues.

"WORKING TOGETHER TO IMPROVE SCIENCE TEACHING AND LEARNING"

PEOPLE

MUSEC Staff

Director: Sandra Abell
Assistant: Marilyn Estes
Project Coordinator:
Marilyn Soucie

Office of Science Outreach

Director: Anna Waldron
Program Coordinator:
Lianne Hibbert

Annual Report Editor

Aaron Sickel

MUSEC Faculty

Lloyd Barrow
Patricia Friedrichsen
Deborah Hanuscin
Marcelle Siegel
Mark Volkmann

Collaborating Faculty

The MUSEC faculty work with scientists and engineers across the MU campus, and with science teachers and leaders across the state.

MUSEC Advisory Board

Shaun Bates
Irvin Cockriel
John David
Mel George
Gerald Hazelbauer
Peter Pfeifer
James Spain
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