CREATE for STEM

MICHIGAN STATE UNIVERSITY | College of Education
CREATE for STEM is a Michigan State University-sponsored research institute with a broad mandate for Collaborative Research in Education, Assessment and Teaching Environments for the fields of Science, Technology, Engineering and Mathematics.
CREATE for STEM is a Michigan State University-sponsored research institute with a broad mandate for Collaborative Research in Education, Assessment and Teaching Environments for the fields of Science, Technology, Engineering and Mathematics. Our goals are to improve teaching and learning in the STEM disciplines for students from grades K–16 through research and development efforts. We bring together STEM faculty from the College of Education and serve as a springboard and a hub for innovation, research and intellectual collaboration, and helping to bring to fruition ideas and projects that will make a difference in the teaching and learning of STEM for all learners regardless of their cultures or experiences.

Within each of our focus areas, we build interdisciplinary and intergenerational research groups, foster new talent and support the grant writing process. CREATE is also a hub for the exchange of information and ideas, sponsoring conferences, workshops, seminars and visiting scholars to enhance interest in STEM education and develop capacity in the field here at MSU.
OUR GOALS

WITHIN THE STEM EDUCATION FIELDS, WE AIM TO:

- **Innovate** by being on the forefront of developing new curriculum materials, use of technology, professional development, policy approaches and research methods to improve teaching and learning;

- **Investigate** by researching the effectiveness of innovations in the fields of STEM education; and

- **Inform** by publishing research and other materials to researchers, teachers, scientists and policymakers to support continued improvement in both understanding and outcomes in the field.

CREATE HAS FIVE MAJOR FOCUS AREAS FOR ITS WORK:

- Creating and Investigating Change in K-16 STEM Education
- Educational Policy in STEM Fields
- Discipline-Based Undergraduate STEM Education
- Developing Innovative and Digital Materials
- International Engagement with the Global STEM Education Community
NGSS-RELATED PROJECTS AT CREATE for STEM

Many of the research and innovation projects underway at CREATE for STEM are intended to transform traditional curriculum and pedagogy through the principles of project-based learning (PBL). PBL enables students to develop useable science knowledge by immersing them in driving questions, investigations and collaboration. Students engage in the co-construction of an understanding of the natural and design world by answering questions related to phenomena or developing solutions to problems.

Project-based learning provides an instructional framework and learning environments that engage students in finding solutions to questions about the world around them. Because PBL immerses students in problems of interest, it is sensitive to the varied needs of diverse students with respect to culture, race and gender. Furthermore, PBL engages students in reading, listening, speaking and writing in science.

INTERACTIONS: STUDENT UNDERSTANDING OF INTERMOLECULAR FORCES

This is a collaboration with researchers from the University of Michigan and the Concord Consortium to design, develop and test a 9th grade physical sciences course that prepares students to explain observations of physical properties and processes based on the electrical interactions of matter, from static cling to the life cycle of hurricanes. The materials combine classroom activities with computer-generated simulations to allow students to actively investigate sophisticated science concepts.

This research is answering two major questions: (1) How does learning progress over time when students experience a set of interdisciplinary instructional materials designed to help them progress toward important learning goals related to interactions at very small scales? and (2) How do the various learning activities support the development of integrated understanding?

Funding: National Science Foundation

TEACHING SCIENCE OUTDOORS PROJECT

CREATE staff are collaborating with partners from MSU Kellogg Biological Station on the Teaching Science Out of Doors Project to build a professional development program for elementary school teachers. The goal of this effort is to increase the ability of teachers to use the outdoors—whether in their schoolyard, neighborhood or community—as a component of doing strong science teaching aligned with NGSS.

Funding: CREATE for STEM & Kellogg Biological Station

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SCIENCE EDUCATION PARTNERSHIP AWARD (SEPA)
PROJECT: A NEW GENOMIC FRAMEWORK FOR SCHOOLS AND COMMUNITIES

This project is developing and assessing new digital curriculum materials for middle school science classes that focus on modern views of inheritance and the development of traits through the interplay between genetics and the environment across time. These materials give students and community members opportunities to apply to their lives ideas about gene-environment interactions, natural selection and evolution. Museum exhibits will elaborate on topics covered in the curriculum, providing evidence for student classroom-assigned projects. Libraries and community-based organizations will host events at which students will share their work and discuss ethical, social and policy issues related to genomics with their parents and other adults. Students will take field trips to genomics research facilities, and genomics professionals will visit classrooms. These informal science education activities will be planned to strengthen student learning while advancing genomic literacy among the community.

Funding: National Institute of Health

INVESTIGATING HOW STUDENTS BUILD AN INTEGRATED UNDERSTANDING OF ENERGY OVER TIME

This CREATE project, with partners from Israel and Germany, is developing both innovative curriculum and a set of assessments to determine which instructional approach is most effective in helping middle school students build a robust understanding of energy. The goal is for students to understand energy as both a disciplinary core idea within individual areas of science and a crosscutting concept that spans the sciences. Assessments will capture student learning, student learning trajectories and student self-efficacy—the degree to which students feel confident in their ability to apply their understanding of energy concepts to explain phenomena they encounter at school and in the world.

Funding: National Science Foundation
TOOLS FOR TEACHING AND LEARNING ENGINEERING PRACTICES: PATHWAYS TOWARDS PRODUCTIVE IDENTITY DEVELOPMENT IN ENGINEERING (I-ENGINEERING)

Achievement and interest gaps remain in engineering for students from underrepresented backgrounds. The STEM education field needs research and development that addresses both the learning problem—supporting students in learning engineering design—and the identity problem—supporting students in recognizing that they belong in engineering. By engaging students in both the technical and social dimensions of engineering design, students both learn important engineering practices and develop a personal identity of being an engineer that can lead to a long-term commitment to STEM study and future careers.

**Funding: National Science Foundation**

MULTIPLE LITERACIES IN PROJECT-BASED LEARNING

This pioneering curriculum effort will use project-based learning to help students in grades 3–4 develop not only scientific understanding aligned to NGSS, but also the language and mathematical literacies that will enable them to thrive as students in later grades and explain phenomena they experience in their lives.

Integrating state-of-the-art technology into the curriculum and instruction, researchers will design materials iteratively over the course of the five-year project. Building upon central principles, and incorporating educative support for teachers, student and teacher materials will be assessed using pilot and field test studies to ensure that the materials work as intended and promote student learning as expected. Particular attention will be paid to the knowledge that coherent materials can foster deeper, more integrated understanding of challenging science ideas that can prepare all students to become scientifically literate and prepared for career, college and community engagement. Additionally, this project will focus on developing student efficacy and agency.

**Funding: George Lucas Educational Foundation**
DESIGNING ASSESSMENTS IN PHYSICAL SCIENCE TO ALIGN WITH THREE DIMENSIONAL LEARNING

The goal of this project is to develop next-generation assessments that address core ideas in physical science—matter and its interactions and energy—by integrating middle school chemistry content with two important scientific practices, constructing explanations and developing and using models.

Assessments are being iteratively designed and administered in middle school science classrooms to ensure usability. Moreover, they are being administered across grade levels to enable an examination of how students might progress over time in their ability to use scientific practices in the context of chemistry content.

The work includes expert reviews of alignment with the National Research Council's Framework for K–12 Science Education and the NGSS. Data is being collected from students in physical science classes in middle schools in three school districts in Florida and one in Wisconsin. A unique feature of the project is the inclusion of teachers in co-developing resources for formative use of the assessments.

**Funding: National Science Foundation**

GETTING TO KNOW THE NEXT GENERATION SCIENCE STANDARDS

This is a set of eight online workshops developed by CREATE staff and partners from the Michigan NGSS External Review Team for teacher professional development. The materials are in-depth and incorporate instructional components, including activities to support teacher interaction with the content. This work and related professional development support for NGSS in Michigan are funded internally by CREATE.

**Funding: CREATE for STEM**
SUPPORTING SECONDARY STUDENTS IN BUILDING EXTERNAL MODELS

This three-year project is (1) developing and testing a modeling tool and accompanying instructional materials, (2) exploring how to support students in building and using models to explain and predict phenomena across a range of disciplines and (3) documenting the sophistication of understanding of disciplinary core ideas that students develop when building and using models in grades 6–12. The project is, thus, engaging learners in using crosscutting concepts with various scientific practices (particularly modeling, but also analyzing and interpreting data and engaging in argument with evidence), blended with disciplinary core ideas. Because the research and development work will be carried out in schools in which students typically do not succeed in science, the products will also help produce a population of citizens capable of continuing further STEM learning.

Funding: National Science Foundation

ASSESSING LEARNING PROGRESSIONS

Assessing Learning Progressions (ALPs) is a project aimed at helping researchers of learning progressions bridge the gap between the development of hypothetical learning progressions and the use of assessment to study and validate them. Learning progressions have the potential to transform how we construe learning, instruction and assessment in science.

Funding: National Science Foundation
HIGHER EDUCATION PROJECTS

PROJECTS AND PRACTICES IN PHYSICS (P³)

p³ ("p cubed") is a community-based learning environment for introductory mechanics that begins to investigate how students learn to engage with scientific practices while learning physics content. The project focuses on transforming introductory mechanics course by having students engage in computational modeling of physical phenomena. Through the study of complex problems and the use of computational projects, students learn core physics concepts while engaging in the practices of doing science.

Funding: CREATE for STEM (National Science Foundation Pending)

AUTOMATED ANALYSIS OF CONSTRUCTED RESPONSE

This collaboration of researchers from seven universities is exploring the use of computerized lexical analysis of student writing in large enrollment undergraduate STEM courses. It has created libraries that categorize student responses with over 90% accuracy. These categories can be used to predict expert ratings of student responses with accuracy approaching inter-rater reliability among expert raters. This approach also provides insight into student use of analogical thinking, a fundamental part of scientific modeling. These techniques have potential for improving assessment practices across STEM disciplines.

Funding: CREATE for STEM & National Science Foundation

INTRODUCTORY COURSE AND CURRICULUM DEVELOPMENT

CREATE for STEM is part of a five-year, $1.5 million award to Michigan State University from the Howard Hughes Medical Institute for Introductory Course and Curriculum Development to improve introductory courses that serve as gateways to continued studies in science, technology, engineering and mathematics. MSU’s approach will transform introductory STEM courses to emphasize core scientific and mathematical ideas and practices that are common across different disciplines. This emphasis will improve student learning, raise student engagement and increase the number of students graduating with STEM degrees. These efforts also will change the institutional culture of MSU to focus even more on STEM student learning and success. Specific projects will include reform and revision of chemistry and physics laboratory courses, the creation of digital evolution education software modules in biology and the development of a new modeling-based calculus curriculum.

Funding: Howard Hughes Medical Institute
TEAM (TEACHER EDUCATION AND MATHEMATICS)

This project is improving remedial mathematics education at MSU while helping pre-service mathematics teachers learn to teach. The project is transforming instruction in MTH100E, the face-to-face enrichment course connected with MTH1825, a remedial algebra course at MSU.

This transformation began with implementation of a problem-based curriculum in a limited number of sections in MTH100E in fall 2012, with future mathematics teachers as the instructors. The future high school math teachers were enrolled in a mathematics teaching methods class (TE407), and the MTH100E class served as the lab for the teaching methods course. Struggling mathematics students at MSU therefore get the benefit of engaging with young and enthusiastic mathematics instructors using current research-based practice, while those future teachers receive an authentic practice teaching experience helping real students struggling with mathematics.

Funding: CREATE for STEM & National Science Foundation

CREATING A COHERENT GATEWAY FOR STEM TEACHING AND LEARNING AT MSU

This project endeavors to change the culture at Michigan State University so that teaching and learning are valued and rewarded. The primary mechanisms to enact this change are (1) helping individual departments develop a shared vision for their gateway courses and (2) developing policies and structures to support and reward curricular improvements.

This effort builds on the 3-dimensional learning model of the NRC Framework, and engages scientists in identifying the Core Disciplinary Ideas in their fields that must be addressed in Gateway sequences. Baseline data is being gathered in gateway Biology, Chemistry and Physics courses here on campus to develop a description of what is currently happening in gateway courses. Additionally, rubrics to evaluate course materials and instructional practices are being developed to aid both researchers and faculty in evaluating curriculum. Last, but not least, efforts to pilot course transformations are also underway in gateway courses in all three disciplines.

Funding: Association of American Universities
CREATE for STEM holds a yearly miniconference at MSU that provides faculty, postdocs, graduate students, teachers, administrators and other educational leaders opportunities to share and discuss their work to promote the teaching and learning of science, technology, engineering, and mathematics in K–16 through research.

The institute is also proud to sponsor three major seminar series for the MSU community and colleagues in the surrounding area. Each series is open to the public, and welcomes practitioners, investigators and colleagues from across campus and beyond.

**Co-Integrate Mathematics Seminar Series**
This monthly series features talks by MSU faculty and graduate students who are working on projects to improve math teaching and learning at MSU and in Michigan more broadly.

**CREATE Work-in-Progress Brown Bags**
The Work-in-Progress brown bags are designed so that researchers can share their current research and get friendly help, insight and ideas from others in the local community.

**CREATE Science Seminar Series**
These provide a venue to disseminate and discuss innovative research methods and results, to foster relationships and networking with national and international experts in STEM education research and ultimately to help solve challenging problems in the teaching and learning of science, K–16.
The **CREATE for STEM** Institute supports a number of collaborative groups, both within and across disciplines, designed to encourage innovation and research in the STEM disciplines.

**Discipline-Based Educational Research**
The Discipline-Based Educational Research (DBER) group at CREATE is a gathering of scientists, mathematicians and engineers who are grounded in their respective STEM disciplines and who have a research interest or focus on investigating and improving education, particularly at the undergraduate level.

**DBER Grad Students**
As an organization of graduate students interested in pursuing EBER as it relates to the STEM disciplines, this group provides a community of peers to discuss issues related to DBER, provide constructive critical feedback on members’ research, share resources and facilitate networking and interdisciplinary collaboration.

**DBER Journal Club**
The DBER Journal Club is a reading and discussion group for post-docs and graduate students to learn about and develop this research field together, as well as build collaborations within MSU.

**K-12 Science Education Research**
This is a special interest group at CREATE for all those who are interested in any aspect of science education and science education research at the kindergarten through secondary level.

**STEM Alliance**
The STEM Alliance is composed of the MSU colleges, institutes and research groups engaged together in an effort to make Michigan State the premier public university for undergraduate STEM learning and research.

**Mathematics Education Research Group**
This group is for those interested in all levels of mathematics education and mathematics education research, including K-12 teachers and administrators, ISD and MDE staff, faculty and graduate students from PRIME, TE, CEPSE, Math, Statistics and other departments.

**Physics Education Research Lab**
PERL@MSU is an interdisciplinary collaboration that studies how students learn physics and engage in physics practice, social and contextual factors that promote student learning and engagement, assessments (conceptual learning, epistemology and practice) and educational technology use and practice.

**Science and Society @ State (S3)**
The purpose of S3 is to foster interdisciplinary collaboration among colleagues across campus who have an interest in combining STEM, health research or teaching with scholarship and methods from the range of scholars who use social science and/or humanistic approaches to study science.

**Science Education**
The mission of science education is to blend science theory, research and practical application to explore current issues in science teaching and learning. An impressive group of faculty, post-doctoral researchers, graduate students and undergraduates in science education bring a range of theoretical and methodological perspectives to their work, including cognition, sociocultural and feminist/critical perspectives using both qualitative and quantitative methods.
Professor Joseph Krajcik is the Lappan-Phillips Chair of Science Education at Michigan State University and director of the CREATE for STEM Institute. A former high school chemistry and physical science teacher, Krajcik spent 21 years at the University of Michigan before coming to MSU in 2011. During his career, he has focused on working with science teachers to reform science teaching practices so as to promote student engagement in and learning of science. He co-led the effort to develop the disciplinary core ideas in physical science for the Framework for K–12 Science Education and chaired the Physical Science Design Team for the Next Generation Science Standards.

Krajcik has just completed a five-year term term as co-editor of the Journal of Research in Science Teaching, the top ranked research journal in the field of science education worldwide. He has authored and co-authored curriculum materials, books, software and over 100 manuscripts, and makes frequent presentations at international, national and regional conferences. He is a fellow of the American Association for the Advancement of Science and has served as president of the National Association for Research in Science Teaching (NARST), from which he received the Distinguished Contributions to Science Education Through Research Award in 2010.

Krajcik also received the 2014 George G. Mallinson Award from the Michigan Science Teachers Association for overall excellence of contributions to science education over a significant period of time.

CREATE offers numerous possibilities for bringing about positive change through development, innovation and research. We are ready to assist interested colleagues who would like to become involved in addressing the challenges of STEM education in the disciplines, and we welcome your involvement, insights and creative talents! If you would like more information or would be interested in talking with the institute, please contact us at:

http://www.create4stem.msu.edu/contact
CREATE is also a hub for the exchange of information and ideas, sponsoring conferences, workshops, seminars and visiting scholars to enhance interest in STEM education and develop capacity in the field here at MSU.