Discipline-Based dB-SERC Science Education Research Center

DISCIPLINE-BASED SCIENCE EDUCATION RESEARCH CENTER FUNDS PROPOSALS FOR IMPROVING TEACHING & LEARNING IN THE NATURAL SCIENCE DEPARTMENTS

The Discipline-Based Science Education Research Center (dB-SERC), created in 2014 by the Dietrich School of Arts and Sciences, has awarded Course Transformation Awards to ten faculty members this year who have developed projects that intend to bring innovation to the teaching and learning in the natural sciences. Course transformation awards fund projects that seek to improve student learning outcomes by adopting and adapting evidence-based teaching practices.

Developing and Testing a Classroom-Based Social-Belonging Intervention to Address the Effects of Stereotype Threat on Female Physics Students

Project Director: Kevin R. Binning, Department of Psychology, Learning Research and Development Center

Many women contend with negative stereotypes about their abilities and harbor doubts about their belonging in STEM fields. This project seeks to transform how female students experience an undergraduate physics course for physical scientists and engineers. The course transformation involves developing and implementing a classroom-based small-group social-belonging intervention tailored to address the stereotypes and belonging concerns held by many female physics students. The intervention has the potential to improve the immediate and long-term outcomes for female physics students, and the results may lead to the widespread adoption of social belonging interventions in college STEM classrooms to address current and historical gender disparities.

Engaging student scientists to enhance understanding of forest degradation and promote inquiry-based scientific skills

Project director: Walter P. Carson, Department of Biological Sciences

Dr. Carson plans to engage students enrolled in an Ecology Laboratory class in hypothesis testing so as to enhance their understanding of habitat degradation in an urban forest. Students will work in teams to generate their own hypotheses as to why urban forests throughout the eastern United States are degrading. They will then develop a research plan to test their hypotheses and present a talk presenting their research plans to the class. All students will also participate in a field trip to an urban forest (Eden Hall Campus of Chatham University) where they will collect real data to test their hypotheses. Students will then use these data to write a complete scientific paper in the format typically required by scientific journals. Students in the Ecology Laboratory class will return to this same forest each fall and thus students in subsequent classes can build upon data collected by classes in previous years. Over time, student scientists will be able to evaluate multiple hypotheses that hone in on the causes forest change. The forest will ultimately serve as a showcase of urban forest restoration for both educational and research purposes.

Creating an undergraduate course for Principles of Data Science

Project director: Sungkyu Jung, Department of Statistics

To meet the increasing demand from undergraduate students on proper data science training and to provide students with a principled introduction to data science that properly combines inferential thinking and computational thinking, there is a pressing need for the development of undergraduate courses for data science. In order to address these issues, Dr. Jung will develop a new course "Principles of Data Science." In this course, students will learn the fundamental pipeline of data science, ranging from data acquisition, data clean-up, data exploration and visualization, modeling and inference, and professional reporting. These topics are carefully curated to engage students in "thinking with data". The new course will play a central role in the anticipated future developments of Data Science Major, Minor or Certificates, and has a potential to be extended to a masters-level data-science-introduction course at the University of Pittsburgh.

Repeating students in Biology 1

Project director: Nancy Kaufmann, Department of Biological Sciences

Each spring term, approximately twenty to thirty percent of the students enrolled in Biology 1 repeat the course. Many of these students struggle and often fail the course again. Dr. Kaufmann will perform a historical analysis of past repeating students and develop a simple intervention in which repeating students will read about successful paths of past repeater students. After reading about the successes of others, the repeating students will develop and articulate a written plan that includes their strategies for success in the course. Dr. Kaufmann plans to design support systems and interventions to help these students be successful and investigate whether addressing motivation and mindset increases repeater success in the Biology 1 course.

Learning with hierarchical templates

Projector director: Kirill Kiselyov, Department of Biological Sciences

The goal of Dr. Kiselyov's project is to incorporate hierarchical templates in his Cell Biology course as a learning aid. Cell biology involves many advanced concepts and complex tasks, such as connecting observations, reinterpreting findings in a specific experimental context, and making conclusions. To address this complexity, Dr. Kiselyov will implement and assess the practice of using fillable hierarchical templates representing "maps" of information learned in class or from manuscripts. The templates will graphically represent different levels of information (observations, conclusions, hypotheses) and relations between them. The templates will be filled by the students and analyzed by the instructor and their peers. The approach is expected to help students organize and understand complex information and will serve as an assessment tool, or a "map," of students' learning and difficulties.

Transforming Math Education for Chemists

Project director: Daniel Lambrecht, Department of Chemistry

Dr. Lambrecht will transform mathematics education for chemistry majors by developing guided inquiry learning activities around chemistry-specific applications of mathematics. His central goal is to empower chemistry majors with general problem solving skills to tackle problems in physical chemistry. Students will learn to translate between different models in physical chemistry, such as different mathematical models or intuitive chemical pictures, break down realistic chemistry problems into manageable sub-problems, select appropriate mathematical models, solve these models by the help of computer-based algebra systems, evaluate the validity and limits of these models, and interpret the results. This approach will allow students' to focus on problem solving within the context of chemistry specific mathematical applications that form the basis for subsequent upper-level classes. Dr. Lambrecht expects that this course transformation will enhance learning outcomes by providing a more engaging environment and will serve students well in their upper division courses, in research, and at the workplace.

An Interdisciplinary Data Science Design for Undergraduate Students

Projector director: Lucas Mentch, Department of Statistics

Dr. Mentch is developing a new course "Statistical Learning and Data Science" that will serve to modernize the statistics department curriculum to better meet the needs of current and future students. The course will introduce students to modern methods in statistics, data science, and machine learning not covered in other courses and also foster the development of practical programming skills. The specific goals of this project are to develop new slides and course material, design early-stage assignments to ensure an equal starting point before beginning the core material, and to develop low-stakes assessments to provide student and instructor feedback as to whether the most crucial aspects of the material are being comprehended at an appropriate level. The skills and methods learned in this course will be directly transferrable to industry positions while and can also serve as a solid foundation on which to build knowledge in graduate school.

Expanding the physics exploration center with virtual experiments

Project director: David Nero, Department of Physics and Astronomy

Each semester, hundreds of students in introductory physics courses visit the Physics Exploration Center (PEC) to work with hands-on physics experiments at their own pace. These experiments are designed to lead students to a stronger conceptual understanding of physics by challenging their preconceptions of the physical world. Unfortunately, the scope of experiments that are practical to include at the PEC is limited because students need to be able to complete the experiments with minimal guidance, which excludes many potential learning opportunities because the equipment is difficult to use without training. Dr. Nero will create a "virtual lab" to be hosted at the PEC. He will design twelve new experiments for the PEC which will be recorded using a 360 degree 3-D camera. Students will view these experiments at the PEC using a virtual reality headset. The combination of a headset paired with 360 degree 3-D video will give students the sensory experience of actually standing in front of the equipment. The student will then proceed with data analysis as if they had just collected the data themselves. Dr. Nero hopes that the new virtual experiments will improve student attitudes about physics and learning.

Relevant and Inquiry Based Laboratory Experiences for the Honors General Chemistry Curriculum

Project director: Eugene Wagner, Department of Chemistry

The Honors General Chemistry course includes a weekly laboratory component to provide opportunities for students to put to practice the ideas and concepts they have learned in lecture. Dr. Wagner proposes to rejuvenate and align the honors general chemistry laboratory curriculum and pedagogy to include guided and open inquiry exploration as well as critical discourse. Eight experiments will be adapted and revised to include guided inquiry followed by open-ended inquiry allowing students to design experiments and test their own hypotheses. Students will work with partners to foster discussion and collaboration. Written critical discourse will be enhanced by creating lab report grading rubrics designed to incentivize students for discussion of chemical concepts, analysis of results, and reflection on their experiment design. The course transformation can serve as the beginning of a significant leap forward in the general chemistry laboratory program.

Incorporating Cooperative Learning Activities into Introduction to Environmental Science

Project director: Kyle Ann Whittinghill, Department of Geology and Environmental science

Dr. Whittinghill proposes to incorporate student-centered active learning activities into the course "Introduction to Environmental Science." She will develop and adapt cooperative learning activities tied to course content learning goals to replace one of two traditional lectures each week. Additionally, for each recitation, she will develop a pre-recitation video lecture to standardize instruction across different teaching assistants and make connections between lecture and recitation. She has chosen to use process oriented guided inquiry learning in the course because it integrates mastery of discipline based content and the development of communication, teamwork, management, and problem-solving skills and has been successfully integrated in large classes. Her ultimate goals for the project are to improve student understanding and retention of course content, increase student engagement in lecture and recitation, and better integrate recitation and lecture material.