Session Abstract
Friday, January 22, 10:30-11:45 am

A Kaleidoscope of Perspectives on Institutional Transformation, STEM & Beyond
Questions that drove the thinking and planning and dreaming of the first cadre of PKAL leaders centered around getting students to share the passion of STEM practitioners (their faculty), to understand the power and potential, connectedness and relevance of the STEM disciplines "…from the very first day." Twenty years ago, the documented dismalness of the lower level STEM courses was a major catalyst for mobilizing pioneering efforts to reinvent what students experienced 'from the very first day.' It is time to refocus on the lower level STEM courses, recognizing although that much has been accomplished, much still needs to be done if all students are to become engaged STEM learners. It is time to consider lessons learned on campuses where systemic and sustainable transformation is visible and to translate their experiences into a broader agenda for action—at the local level and within the PKAL/AAC&U partnership. A new generation of PKAL leaders will describe their experiences in shaping a communal sense of how lower level STEM courses serve the institutional mission; motivate all students to consider careers in related fields—from K-12 science/math teacher to an engineer working on global environment issues; and prepare all students for leadership in these challenging times.

***Facilitator**: **Jeanne Narum**, Founding Director of Project Kaleidoscope*

***Presenters**: **Robin Bingham**, Professor of Biology, Western State College of Colorado; **Katayoun Chamany**, Associate Professor, Science, Technology and Society Program, Eugene Lang College, The New School for Liberal Arts; **Kelly McConnaughay,** Associate Dean of Liberal Arts and Sciences, Bradley University; **Alison Morrison-Shetlar**, Vice Provost and Dean of Undergraduate Studies, University of Central Florida; **Kyle Seifert**, Assistant Professor of Biology, James Madison University; **Scott Van Bramer**, Professor of Chemistry & Department Chair, Widener University*

Bradley University

Kelly D. McConnaughay, Associate Dean of Liberal Arts and Sciences & Professor of Biology
PKAL F21 Class of 1996 *kdm@bumail.bradley.edu*

Name of course/program: Science for Educators (Science 101)

Course description: Science 101 is an interdisciplinary, inquiry-based science course for education majors that incorporates science content and science investigation skills development. The interdisciplinary nature of science is emphasized by focusing on a specific theme (e.g., energy) and presenting the theme from life and physical science perspectives. The scientific method and inquiry as means of understanding natural phenomena are priority foci. Students are expected to start asking questions and develop testable hypotheses on the first day of class. Lecture and student-developed labs are fully integrated, with each portion of the course used to reinforce and expand on the ideas developed in the other.

Students served (majors/all students, first-year, etc.): Early Childhood, Elementary Education, Special Education, and Secondary Education majors

Learning goals established for the course: Our primary goal was to develop a course that would provide pre-service teachers with the background necessary to teach inquiry-based, investigative science. In addition to increasing students' science content knowledge and process skills development, we expect to see gains in students' attitudes towards science and the teaching of science and students' science and science teaching self-efficacy scores.

Significant pedagogical strategies employed in the course: Science content mastery and process skills development are facilitated through a combination of lecture, discussion, inquiry, and laboratory investigation. Students engage in student-driven investigative science laboratory projects in collaborative and highly mentored teams.

Data on level of success in meeting those learning goals: Through Science 101, students' confidence in their ability to teach science significantly increased, as did their awareness of the nature of science and of inquiry science instruction, and their belief in their ability to influence their students' attitudes towards science. There was a decrease in the degree to which students expressed agreement with gender stereotypes regarding science. Student content mastery was higher for education majors taking Science 101 vs. traditional lecture courses. Content mastery was greater for Science 101 students regardless of theme and topic, and content mastery in evolution, a particularly difficult content area for many students, was higher in Science 101 students. Higher content mastery scores were obtained on Science 101 content exams and quizzes despite a greater percentage of analysis and application questions than were found in assessments from the traditional lecture courses. Details of data analysis and results may be found in Edgcomb, Britner, McConnaughay, and Wolffe (2008).

One or two really interesting things about the process of imagining, designing,implementing, and assessing the course that everyone should know about and consider adapting.

- This course was designed by a multi-disciplinary, multi-institutional team, with leadership from the Departments of Biology and Teacher Education and participation by faculty in the Departments of Chemistry and Biochemistry, Physics, and Mathematics, the College of Engineering and Technology, and master teachers and administrators from local school districts in the region.

- The course design was constructed to instruct by example, aligning the course with both the Illinois Learning Standards (ILS) and the NSES and utilizing teaching methods supported by advances in cognitive science.

Edgcomb, M., S.L. Britner, K. McConnaughay, & R. Wolffe (2008) Science 101: An integrated, inquiry-oriented science course for education majors. Journal of College Science Teaching 38(1):22-27.

Eugene Lang College, The New School for Liberal Arts

Katayoun Chamany, Associate Professor, Department of Natural Sciences and Mathematics
PKAL F21 Class of 1998 *chamanyk@newschool.edu*

Name of Course: The Science and Politics of Stem Cells (SPSC)
Program: Interdisciplinary Science Program

Course Description: SPSC uses an interdisciplinary approach to understand the field of stem cell research within a social justice framework. . The fundamental principles and methods of cell biology are framed by readings and resources from the social sciences as well as policy hearings and reports at the local, national, and international level that address the political and social justice dimensions of this field. Case topics include: the ethics of oocyte donation; access and representation in stem cell banks; and the history of the HeLa cell line as it relates to contemporary practice of obtaining informed consent and determining the ownership of biological material.

Students served (majors/all students, first-year, etc.): This course is open to students at all undergraduate divisions of the university, however, students can satisfy matriculation requirements without completing a STEM course. Therefore, this course was specifically designed to attract a more diverse group of students and to engage with students who do not see STEM learning as important to the communities in which they live and work.

Learning goals established for the course:

- To become familiar with controversies surrounding stem cell research and the existing and emerging regulatory bodies that guide the direction of the research.
- To become familiar with the history of cell culture and biotechnology
- To possess a conceptual understanding of cell signaling and differentiation and the important roles they play in reproduction, development, and death.
- To understand the scope and limits of stem cell research in addressing basic biological questions and social ills
- To design experiments to answer questions about stem cell research and developmental biology
- To apply cell biological knowledge to critically read and analyze scientific literature.
- To communicate their understanding of stem cell research in different formats that appeal to a wide range of audiences through the incorporation ethical, social and legal perspectives of this field of research.

Significant pedagogical strategies employed in the course: This course received academic and financial support through an institutional grant as part of Project Pericles to support the production of student-generated projects and learning activities that promote civic engagement. In addition, the curriculum was loosely based on a self-designed case-based curriculum on stem cell biology (GarlandScience). Lastly, the course used a social justice framework and this proved to be vital in the success of the course.

Data on level of success in meeting those learning goals: The civic engagement component included seven different student projects focused on public outreach, and students reported that these activities are what encouraged them to make the scientific content their own. Their confidence to learn and teach biology was greatly improved and many found themselves in conversation with friends and family regarding the course content. Assessment of students learning and affect included qualitative and quantitative data that emerged from standard pre/post biological content exams that use a performance task approach, pre/post attitudinal surveys, and commentary on midterm and end-of-term project reports.

- The course was successful in attracting a diverse student body: 33% URMs and 53% freshman.
- 33% experienced an attitude shift and have registered for more STEM courses
- 53% stated that the civic engagement component was essential to learning
- 63% of the undeclared freshman have chosen Interdisciplinary Science as their major or minor.
- Content and process knowledge of biology was increased in all students and dramatically in 80%
- The first New School Student Organization focused on science was founded by four students in this course
- Sample student quote: "This project engaged me in the class in a way that a regular lecture class could never have achieved. The science certainly fascinated me, but I never would have noticed how interested I was if I hadn't been forced to think critically and engage actively in the class project. If I do end up as a scientist, this class will definitely have laid groundwork for how I will think about scientific ethics in the future."

Lastly, the course has led to interest from faculty in Design, Religious Studies, Law, Gender Studies, and Bioethics and we have received state funding from NYSTEM to develop a core stem cell curriculum based on this approach.

One or two really interesting things about the process of imagining, designing, implementing, and assessing the course that everyone should know about and consider adapting.

Stepping outside the STEM disciplines and coordinating the development of student-developed civic engagement projects was challenging and might have been impossible without the support of the college and SENCER (Science Education for New Civic Engagements and Responsibilities). The course proposal was selected as part of the Dean's Initiative to expand Project Pericles activities on campus and to more deeply connect civic engagement to the college curriculum. An internal civic engagement grant provided time to develop the course materials specific to the social justice perspective, financial support to host a one-day workshop on campus, stipends for a public film and panel series on stem cell research, and a trip to Washinton DC to share the student projects with local policymakers through the SENCER Capital Hill Symposium. Two students were selected to be class representatives for the trip, and together we produced a poster on the course activities and handouts of policy proposals for state appropriated funds for science education and stem cell research. Being able to share challenges and ideas with others involved in civic engagement education through Project Pericles on our campus and SENCER nationwide, gave me the tools and confidence to develop and implement the curriculum, but it was the level of student engagement that convinced me that this approach truly leads to life long learning and curiosity in the scientific endeavor.

Chamany, K. Allen, D. and Tanner, K. (2008). Making biology learning relevant to students: Integrating people, history, and context into college biology teaching. CBE Life Sci Educ 6, 251-258.

Approaches to Biology Teaching and Learning column. CBE-LSE: The ASCB Education Journal. http://www.lifescied.org/cgi/collection/approaches_to_biology_teaching_and_learning A collection of articles on biology education using new pedagogies and assessments.

James Madison University

Kyle Seifert, Assistant Professor of Biology
PKAL F21 Class of 2007 *seiferkx@jmu.edu*

Name of course/program: Introductory Biology "core" (Organisms, Ecology and Evolution, Cell and Molecular Biology, Genetics and Development).

Course description/background (from Seifert et al, 2009): Prior to 2002, Biology majors were required to take five courses: Botany, Zoology, Cell Biology, Genetics, and Ecology. Three of these courses contained labs, and the faculty noted that many of the lab exercises involved observations of preserved specimens. Further, there was a developing consensus that a major overarching emphasis in those classes was learning a substantial number of biological facts, with little to no emphasis on quantitative thinking or the process of doing science. We decided that the curriculum needed to be modified dramatically.

In 2002, the Biology Department, funded by a National Science Foundation Course, Curriculum, and Laboratory Improvement grant, implemented four new first- and second-year laboratory courses: 1) Organisms; 2) Ecology and Evolution; 3) Cell and Molecular Biology; and 4) Genetics and Development. These new courses put greater emphasis on applied laboratory skills and experiences than on memorization of facts.

Students served: First and second year Biology majors

Learning goals established for the courses: Faculty spent a considerable amount of time during faculty meetings and retreats establishing a clearly defined set of knowledge (content), skills and experience objectives. These objectives support the two major goals of the new curriculum - producing students fully literate in the scientific process and integrating research experience into the learning environment for all our majors.

Significant pedagogical strategies employed in the courses: The lab experiences were designed to engage students in the process of scientific inquiry. In addition, these courses were sequenced and integrated, with three lab themes (plants, animals, and microbes) to be investigated in each of the four new courses (Monroe and Hurney, 2002).

Data on level of success in meeting those learning goals: The Biology Department at JMU currently uses a variety of methods to assess students' content knowledge, skills, and experiences. Evidence from the multiple methods of assessment indicates that students are meeting the learning goals. However, many of the assessment instruments either have been modified or are currently being modified to provide more valuable information to the department.

One or two really interesting things about the process of imagining, designing, implementing, and assessing the course that everyone should know about and consider adapting:
Changes this substantial to curriculum require unanimous support from both faculty and administration. Assessment should be incorporated into the plan for change at the very beginning, and faculty must be willing to modify or change the assessment practices if they are not providing the information that is desired.

Monroe, JD and Hurney, CA. (2002). CCLI and Curriculum Change in Biology. CUR Quarterly,22 (3) 122-125. Seifert, K., Hurney, C. A., Wigtil, C. J., and Sundre, D. L., (2009). Using the Academic Skills Inventory to Assess the Biology Major, Assessment Update, 21, (3): 1-2, 14-15.

University of Central Florida

Alison Morrison-Shetlar, Vice Provost & Dean of Undergraduate Studies
PKAL F21 Class of 1997 *aims@mail.ucf.edu;*

Name of course/program: College Algebra

Course description: Each year the College Algebra program supports 2,500 students from all academic programs to foster logical skills, initiative and independence in problem-solving in their day-to-day lives. The course is taught in two modes: students meet one time per week in class and have a mandatory math lab experience where they 'do math' not just watch it, or; students meet three times a week in a traditional classroom environment with no lab requirement. Student retention, success in the course and subsequent courses has been studied and proven to be much higher in the all aspects for those students in the lab experience mode.

Students served (majors/all students, first-year, etc.): All student disciplines, primarily first year, first semester

Learning goals established for the course: foster logical skills, initiative and independence in problem-solving in the day-to-day lives of our students. Retain more students in the STEM discipline.

Significant pedagogical strategies employed in the course: change from classroom instruction only to class and lab experience.

Data on level of success in meeting those learning goals: one example: students success rate of course completion with a c or above has increased from 52% to 74% in two semesters and remained high.

One or two really interesting things about the process of imagining, designing, implementing, and assessing the course that everyone should know about and consider adapting.

This was a president's class size initiative that implemented a variation on the Carol Twigg model of learning. The president provided funding, in time of budget difficulties, to hire faculty, provide technology and assessment resources, and is supported with peer and graduate mentors to assist students in the lab. Support has been provided to develop two additional computer assisted learning labs (200 terminals) for the Math Department and the hope is to develop the same pedagogy in Calculus and Trig courses. The initiative is gaining a great deal of interest from other institutions.

We also have a composition and writing center President's class size initiative that has just recently been implemented, with similar resources and mentoring. Results to date indicate that 2 - 3 times the number of students have been served this year by the Writing Center compared to last year. Also, class size has been reduced from 27 to 25 and there are 8 pilot classes of 19 students with a mandatory writing center component

Western State College of Colorado

Robin A. Bingham, Professor of Biology
PKAL F21 Class of 2001 *rbingham@western.edu*

Name of course/program: SCI 110 Habitable Planet with laboratory
SCI 111 Nature of Science
SCI 120 Living Planet with laboratory
SCI 210 Dynamic Planet with laboratory

Course description: These integrated science courses were designed in order to develop a sustainable science sequence, which addresses the Colorado content standards for K-6 classrooms. The content courses provide an introduction to earth science, ecology, human biology, chemistry, biochemistry, physics, earth science, and space science. SCI 111 is designed as an introduction to science as it relates to the individual, society, and the elementary school classroom. Science is studied as a way of knowing. The process of science is examined, as well as the connection between science as it is done and science in textbooks.

Students served (majors/all students, first-year, etc.): The series is designed for elementary education majors but is open for all students wishing to meet their general education science credits.

Learning goals established for the course: SCI 110, 120, and 210 are all combined lecture and laboratory courses that are designed as part of an integrated science sequence to ensure that elementary teachers are able to teach topics found in the state standards for science. Laboratories are an essential both for an understanding of course content and to give future teachers the confidence to integrate laboratory experienced into their curriculum.

SCI 110 explores earth history, the fossil record, biogeochemical cycles, climate, energy flow, biodiversity, evolution, population growth and regulation. The course meets a portion of the biology standards and a portion of the earth and space science standards.

SCI 111 is an examination of the process of science with some discussion of how science is learned. It is meant as a complement to the three science content courses (SCI 110, SCI 120, SCI 210) for Interdisciplinary Liberal Arts (IDLA) majors. It is an introductory level course taught in a seminar style. While IDLA majors will complete the three content courses with other students, this course is specific to the IDLA major. It will provide an opportunity for these students to meet early in their career at Western and to discover that learning and teaching science can be an enjoyable experience. This course is designed for students seeking licensure as an elementary teacher (grades K-6).

SCI 120 explores anatomy, physiology, nutrition, cell biology, genetics, inorganic chemistry biochemistry, development, and the application of biological and biochemical principles to understanding disease. The course meets a portion of the biology standards and the chemistry standards.

SCI 210 explores motion, force, energy, weather, plate tectonics, earthquakes, volcanoes, and the solar system. The course meets the physics standards and a portion of the earth and space science standards.

Significant pedagogical strategies employed in the course: Faculty have a shared goal of students realizing science is fun and giving them the confidence to incorporate science into their classrooms. Each of the courses is difference enough to help students see different ways of teaching and addressing learning styles.

SCI 110 is team taught by a biologist and geologist. They take many field trips with the idea of using the community to teach science.

SCI 120 uses the theme of disease and culminates with a science fair report project giving the students a little idea of what science fairs involve. It is taught by a molecular/cell biologist.

SCI 210 is team-taught by a physicist and geologist, but in a “tag team” fashion unlike the other science courses. It uses a unique approach of integrated “lab/lecture” to reinforce concepts taught in short lectures with hands-on activities (2-3 activities per 2 hour class period). We stress scientific inquiry, problem solving, critical thinking and creativity by allowing the students to “design” experiments to address a problem or theory discussed in class.

Data on level of success in meeting those learning goals: Collecting assessment data has been a challenge partly due to the number of faculty involved in the courses. Pre and post concept content tests and attitude surveys have been administered.

One or two really interesting things about the process of imagining, designing, implementing, and assessing the course that everyone should know about and consider adapting.

The process by which the courses and curriculum was developed provides a model of effective collaborative work amongst faculty from several science disciplines (geology, chemistry, biology and physics) –plus teacher education. Faculty from these disciplines met over the course of several months to familiarize themselves with the state standards, establish learning goals and outcomes, develop course outlines, and design assessment tools. The group also met with a group of local elementary educators to discuss opportunities and challenges from the perspective of the classroom. After original planning, small groups of faculty including those who would deliver the courses met to develop actual syllabi consistent with goals of larger group.

A unique aspect of SCI 110 Habitable Planet is that it incorporates a semester project where by students investigate an original question. This investigation provides an opportunity to develop skills in the process of inquiry, and forms the basis of a poster presentation which the students present at our fall student research symposium. The goal behind incorporating this experience in this particular class is to provide these students with a genuine and positive experience with the process of science. Preliminary and informal assessments suggest that the course and, specifically the project, succeeds in improving student attitudes toward science.

Widener University

Scott Van Bramer, Professor of Chemistry & Department Chair
PKAL F21 Class of 1998 *svanbram@science.widener.edu*

Name of course/program: General Chemistry I Lab

Course description: This course provides the basic laboratory exercises in general chemistry correlated to the material in CHEM 145. Fundamentals of measurement and quantitative aspects of chemistry are emphasized. The course includes safe handling of solids and liquids, physical separations, inorganic syntheses, solution concentrations, gas laws, energy transfer, micro-scale reactions, and molecular models. 3 hours laboratory. 1 semester hour.

Students served (majors/all students, first-year, etc.): First semester of chemistry laboratory. The course is taken by chemistry majors, biology majors, environmental science majors, and all engineering majors.

Learning goals established for the course:

- Students will be able to properly handle chemical equipment.
- Students will be able to use units and significant figures to represent numerical data.
- Students will understand limiting reagents, be able to correctly identify the limiting reagent in a reaction and determine the yield of a chemical reaction.
- Students will be able to create tables and graphs that clearly represent experimental data.
- Students will understand prudent practices, chemical hygiene, and be able to use MSDS and other safety information to make informed decisions.
- Students will be able to find, cite and use reference data.
- Students will be able to evaluate their experimental results.
- Students will be able to make observations; record their experimental procedure and results; and effectively communicate their experimental results.

Significant pedagogical strategies employed in the course: Students work in POGIL style groups of 3-4 students. Students are given a task or problem and each group is required to design an experimental procedure to address the problem. Drafts of the procedure are reviewed by the instructor and returned with comments. Students record all their data and observations in a laboratory notebook. All data and calculations are done using a spreadsheet and electronically submitted. Each student writes a

2-3 page discussion of their experimental results. Students receive extensive feedback that they are expected to use to improve their work during the semester. Instead of beginning the semester with lengthy introductory material, expectations for student work increases during the semester.

Data on level of success in meeting those learning goals: Based upon evidence from the laboratory practical, the course exams, and student laboratory reports, by the end of the semester almost all students in the course meet the established course goals at a beginner level.

One or two really interesting things about the process of imagining, designing, implementing, and assessing the course that everyone should know about and consider adapting.

The course was originally imagined when four faculty from the department of chemistry attended a PKAL workshop in New York City. The opening session got us talking about our old general chemistry laboratory, how dissatisfied we were with the design of the course and the student outcomes. We laid out a two year plan where this new model was piloted in an honors section of the course, then implemented in a small number of sections during the off sequence semester. Finally, the course was rolled out with all sections and almost all the full time faculty taught a lab section. All the faculty meet weekly to debrief and work through different issues. This was an extremely time consuming process, but the result has been that almost all the faculty in the department are on board with this model of teaching. Since then, most of the laboratory courses in the department have undergone significant change.

From this experience, having a group of faculty get off campus to brainstorm is invaluable. Running a new course as a pilot and then with a small number of sections before rolling it out was wiser than we realized at the beginning. Taking the time for most of the faculty in the department to teach the course and spending an hour each week discussing the course allowed us to leverage innovation in one class across the curriculum. Even faculty who were quite skeptical have made significant changes in their teaching as a result of this experience.

For More Information: http://www.pogil.org/