GK-12: A Multi-Disciplinary Research and Teaching Program in Biomedical Engineering for Discovery and Understanding of Cell Communication

Welcome Graduate Fellows

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Meeting Overview

• Welcome
  • Welcome and introduction (all, 5 min)
• GK-12 project overview
• GK-12 project K-12 activity overview
• STEM in the High School Classroom
• TEAM Stages and TEAM Building – What to expect
• Q&A after lunch
Project Overview

• This inventive program is designed to train a new generation of scientists in biomedical science and engineering who are inter- and multi-disciplinary in their training, better equipped for multilevel communication across ages (GK-12) and fields (engineering, biology, and chemistry), and finally prepared to take leadership roles for scientific inquiry and progress into the 21st century.

• The research component consists of activities in silicon nano scale sensor design, modeling, and understanding how molecules move and the functions of multi-cellular tissues and organ systems. The research is critical for continued understanding and advances in some of the fundamental questions facing biology and medicine, and ultimately our society for better quality of life.

• The educational component consists of activities to advance biomedical engineering and develop a new generation of scientists with transferrable skills. The graduate fellows and doctoral advisors collaborate with K-12 teachers to make new STEM content using engineering approaches accessible to K-12 STEM education. The participation of industry partners provides practical experiences for graduate fellows, teachers, and K-12 students in the program.
Project Partnerships Overview

- Number of STEM graduate fellows per year: 8
- Number of K-12 teachers working with the fellows per year: 8
- Number of K-12 classes anticipated to be served per year: 8 or more
- Number of Schools and School District Partners: 8 high schools from 4 districts.
- Target audience of the project: high school grades.
- Setting: suburban and rural.
Overview of Project Goals

- To provide a unique interdisciplinary and cutting-edge graduate research program to cultivate world class scientists and engineers in bioengineering.
- To equip future scientists and practicing engineers with communication skills that allow them to communicate with their fellow researchers and engineers, and to communicate effectively with the general public and with K-12 teachers and students in particular.
- To provide graduate fellows with additional training of important transferrable skills in global culture and diversity, leadership, civic and public engagement, innovation, and ethics.
- To build knowledge and content capacity for K-12 teachers and to develop new content for K-12 STEM education by incorporating research contents into K-12 curriculum that address the state and national STEM standards and extend their relevance towards challenging K-12 students to engage in inquiry and discovery.
- To create and to strengthen the partnerships between STEM departments at CSU, STEM departments at regional K-12 school districts, and private sector companies involved in the electronics and bioscience industry.
Four Principle Project Activities

• All fellows will be engaged in a coherent and multidisciplinary research theme involving three colleges, four departments, and our industrial partners using systematic engineering approach to biomedical research;

• It provides opportunities for graduate students to interact with K-12 education and industry with transferrable skills that are not part of the traditional graduate training;

• It provides a direct link between exciting new biomedical science discoveries and engineering achievements and advances STEM teacher content knowledge, and brings these advances to the K-12 classroom. The importance of learning STEM subjects in K-12 will be emphasized;

• The participation of local industry provides practical experiences for graduates fellows, teachers, and K-12 students in the program.
Our High School Partnerships

• Partnership with local high schools is a foundational element of this project.
• Multiple CSU departments involved
  – electrical and computer engineering, biomedical sciences, biology, physics, chemistry, and mathematics.
• How can our interdisciplinary team make meaningful contributions and connections at these school? Let’s explore the possibilities...
Fellow Focus

• Fellow’s number one priority is their research and graduate educational progress.
• Fellow’s, supporting teachers as content experts in the classroom.
  – Building a community of scientific inquiry between fellows, teachers, faculty advisors, and K-12 students is an important goal of this project.
  – Collaborating to enhance research content in the classroom
Fellow Focus

• Fellow’s work with their teachers an average of 10 hrs./week on site in the classroom.
• Fellow’s also spend time on campus planning and preparing.
• Collaborative planning and scheduling of demonstrations, inquiry-based experiments, data analysis, and sharing/discussion between and within GK-12 classrooms and teachers is part of the fellows additional 5 hours/week dedicated to this project.
Teacher Role

• Support fellow’s research integration into the classroom will begin with the research and standards-based themes that are developed during the summer workshop and co-developed presentations and laboratory activities taken from the fellow research projects.
Teacher Role

• The teacher is the expert in the art and skill of scientific communication, learning theory, curriculum development, and learning activity planning with an emphasis on inquiry-based learning.

• Helping the fellow make the research content connection accessible to high school students is a key role of the partner teachers.
Principal Role

• Support and recognize teachers for extra time they invest in improving their curriculum, teaching, and project activities.
• Support the research fellow in their role as a STEM content expert assigned to your school.
• Work with STEM curriculum coordinators to support, highlight, and encourage classroom innovation.
• Disseminate the involvement of the project in your school.
  – School and community level recognition
  – District level recognition, sharing with other Principals, district administration, school board.
Together the Teacher and the Fellow

- The collaborative “un-packing” of the research project content into related concepts that can be delivered into the K-12 classroom is the focus of the fellow/teacher/advisor collaboration and participation in the classroom.
- They plan inquiry driven lessons, demonstrations, and standards based instructional modules.
- Together they disseminate their work to other teachers.
Teacher/Fellow Expectations

Summer Activities

• Participate in summer in-service activities.
  – The objective of the summer programs is threefold:
    – 1) to provide hands-on research experiences for K-12 teachers in
      research labs at CSU to enhance their understanding of research
      methods and contents the graduate fellows may bring to the K-12
      classrooms,
    – 2) to provide for learning opportunities for GK-12 fellows and teachers
      to broaden their knowledge base with the industrial residency
      program,
    – 3) to provide opportunities for social interactions between K-12
      teachers, GK-12 fellows and their academic advisors to introduce each
      other and explore mutual interests in pursuing future collaborations.
      The summer programs are especially important for new GK-12 fellows
      and teachers to “date” each other to bring down barriers, and to set
      the context of collaboration not only at the professional level but also
      at the personal level.
Teacher and Fellow Activities
Academic Year

• Participate in project activities and meetings.
• Support fellow’s integration into classroom culture.
• Collaborate with fellow, research advisors, and/or industry partners in the planning, design, and delivery of new STEM content.
• Communicate with all project staff and work in a team environment of sharing and mutual respect.
• Be flexible... things don’t always go as planned.
Key CSU Personnel and Their Roles

• **Tom Chen**, Department of Electrical & Computer Engineering. Responsible for overall project activities and the engineering aspects of the research  
  – chen@engr.colostate.edu
• **Michael de Miranda**, Department of Electrical & Computer Engineering. Responsible for overall educational activities of the project.  
  – mdemira@engr.colostate.edu
• **Stuart Tobet**, Department of Biomedical Sciences, Responsible for biomedical aspects of the research  
  – stuart.tobet@colostate.edu
• **Aaron Benally**, College of Engineering/Project coordinator. Responsible for day-to-day operations of the project.  
  – abennally@engr.colostate.edu
• Other senior personnel: **Chuck Henry** (Department of Chemistry), **Vakhtang Putkaradze** (Department of Mathematics)
Research Proven Strategies in Mathematics
Historical Perspectives:

- Math was taught as a set of facts, rules, and procedures
- Revised standards became known as Principles and Standards for School Mathematics (NCTM, 2000)
- Identified six overarching principles
Current NCTM Standards (K-12):

- Number and Operations
- Algebra
- Geometry
- Measurement
- Data Analysis and Probability
- Problem Solving
- Reasoning and Proof
- Communication
- Connections
- Representations
Suggestions from research:

According to Carnine (1998), five major components are required for effective mathematics instruction. These include:

• Focus on “big ideas”
• Teach “conspicuous” strategies (neither too broad or too specific) (see also Montague, 1998).
For example
Suggestions from research (cont):

• Make efficient use of time on prioritized objectives.

• Communicate strategies in a clear, explicit manner.

• Provide practice and review to promote retention (Mastropieri & Scruggs, 2004; Harniss, Stein, & Carnine, 2000).
Other evidence-based strategies
(Not specific to mathematics instruction)

• Cooperative Learning,

• Mnemonic Instruction,

• Class Wide Peer Tutoring, and

• Direct Instruction (Harniss, Stein, & Carnine, 2000).
Resources

• What Works Clearinghouse
  http://www.w-w-c.org

• National Council for Teachers of Mathematics
  http://www.nctm.org

• The Access Center
  http://www.k8accesscenter.org
Concluding Thoughts

According to the National Research Council (1989):

Mathematics is the key to opportunity. No longer just the language of science, mathematics now contributes in direct and fundamental ways to business, finance, health, and defense. For students, it opens doors to careers. For citizens, it enables informed decisions. For nations, it provides knowledge to compete in a technological economy. To participate fully in the world of the future, America must tap the power of mathematics (p.1).
National Science Education Standards

The Standards are *not*:

• A curriculum
• A test
• A mandate
• A policy
National Science Education Standards

The Standards are criteria that:

• Identify content
• Emphasize understanding
• Link content, teaching and assessment
The Vision

“All students, regardless of gender, cultural or ethnic background, physical or learning disabilities, future aspirations or interest and motivation in science, should have the opportunity to attain high levels of scientific literacy.”
Challenge for Teachers

• Create an environment where you and your students work together as active learners
• Expand your own knowledge about science, learning, and teaching
• Teach in a way that reflects the vision of the Standards
Teaching Standards

• Plan an inquiry-based program
• Guide and facilitate learning
• Assess teaching and learning
• Design and manage learning environments
• Participate in the development of the school’s science program
Professional Development Standards

Professional Development includes:

• Learning through methods of inquiry
• Integrating and applying knowledge of science, learning pedagogy and students to science teaching
• Building lifelong learning
• Coherent and integrated programs
Assessment Standards

Assessment practices:

• Must be consistent with purpose
• Must assess achievement and opportunity to learn
• Must match data with decisions
• Must be fair
• Make sound inferences
Content Standards

Science Standards include:

• Unifying concepts and processes
• Inquiry
• Physical Science
• Life Science
• Earth and Space Science

• Science in Personal and Social Perspectives
• History and Nature of Science
• Science and Technology
Standards for Technological Literacy: Content for the Study of Technology
Terminology

Technology is the modification of the natural environment in order to satisfy perceived human needs and wants.

- Technological literacy is the ability to use, manage, assess, and understand technology.
- Engineering and Technology Education is a study of technology, which provides an opportunity for students to learn about the processes and knowledge related to technology that are needed to solve problems and extend human capabilities.
Three Prevalent Misconceptions

• Technology is applied Science
  “The lack of technological literacy is compounded by one prevalent misconception: When asked to define technology, most individuals reply with the archaic and mostly erroneous, idea that technology is applied science” (Bybee, 2000, pg. 23).

• Equating Engineering and Technology Education with teaching computers and information technology

• Confusing engineering and technology with technical
Technology Education and Educational Technology

Engineering and Technology Education (Technological Studies)
- Teaches about technology
- A school subject
- Ultimate goal: Technological literacy for everyone

Educational Technology (Information Technology)
- Teaches with technology
- A means of teaching
- Ultimate goal: Improving the process of teaching and learning
What *Standards for Technological Literacy* is NOT:

• It is not a curriculum, on the other hand, *Standards for Technological Literacy* can describe overarching goals, or ways in which the curriculum should be orchestrated to achieve a desired result.
  
  – It is our belief that curriculum goals and principles should not be part of a description of content standards.

• *Standards for Technological Literacy* does not prescribe courses or programs (groups of courses)
Guiding Principles Behind
Standards for Technological Literacy

The standards and benchmarks were created with the following guiding principles:

• They offer a common set of expectations for what students should learn in the study of technology.
• They are developmentally appropriate for students.
• They provide a basis for developing meaningful, relevant, and articulated curricula at the local, state, and provincial levels.
• They promote content connections with other fields of study in grades K-12.
• They encourage active and experiential learning.
Who is a technologically literate person?

Understands:

- What engineering and technology is
- How technology is created through engineering
- How the use of technology shapes society and in turn,
- How society shapes the development of technology
The Nature of Technology

- The characteristics and scope of technology
- The core concepts of technology
- The relationships among technologies and the connections between technology and other fields of study

Technology and Society

- The cultural, social, economic, and political effects of technology
- The effects of technology on the environment
- The role of society in the development and use of technology
- The influence of technology on history

Design

- The attributes of design
- Engineering design
- The role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving

Abilities for A Technological World

- Apply the design process
- Use and maintain technological products and systems
- Assess the impact of products and systems

- Medical technologies
- Agricultural and related biotechnologies
- Energy and power technologies
- Information and communication technologies
- Transportation technologies
- Manufacturing technologies
- Construction technologies
Standards vs. Benchmarks

• Standards are the target
  – Benchmarks are provided as a guide to begin implementation, but there may be additional benchmarks needed for your particular situation.
The Nature of Technology

• Std. 1: Students will develop an understanding of the characteristics and scope of technology.
• Std. 2: Students will develop an understanding of the core concepts of technology.
• Std. 3: Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.
Technology and Society

• Std. 4: Students will develop an understanding of the cultural, social, economic, and political effects of technology.
• Std. 5: Students will develop an understanding of the effects of technology on the environment.
• Std. 6: Students will develop an understanding of the role of society in the development and use of technology.
• Std. 7: Students will develop an understanding of the influence of technology on history.
Design

• Std. 8: Students will develop an understanding of the attributes of design.
• Std. 9: Students will develop an understanding of engineering design.
• Std. 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.
Abilities for a Technological World

• Std. 11: Students will develop the abilities to apply the design process.

• Std. 12: Students will develop the abilities to use and maintain technological products and systems.

• Std. 13: Students will develop the abilities to assess the impact of products and systems.
The Designed World

• Std. 14: Students will develop an understanding of and be able to select and use medical technologies.

• Std. 15: Students will develop an understanding of and be able to select and use agricultural and related biotechnologies.

• Std. 16: Students will develop an understanding of and be able to select and use energy and power technologies.

• Std. 17: Students will develop an understanding of and be able to select and use information and communication technologies.
The Designed World cont.:

- Std. 18: Students will develop an understanding of and be able to select and use transportation technologies.
- Std. 19: Students will develop an understanding of and be able to select and use manufacturing technologies.
- Std. 20: Students will develop an understanding of and be able to select and use construction technologies.
THANK YOU!