Georgia Tech STEM Education
Research Expo

Hosted by:

The Georgia Tech Chapter of the American Society for Engineering Education and the College of Engineering

Sponsored by:

Center for the Enhancement of Teaching and Learning (CETL), Center for Education Integrating Science, Mathematics, and Computing (CEISMIC), College of Architecture, College of Computing, College of Management, College of Sciences, and Ivan Allen College

Thursday, January 17th, 2013
Ferst Center Galleries
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The Impact of Georgia Intern-Fellowships (GIFT) for Teachers on K-12 Science Teachers

Meltem Alemdar, College of Science/ Center for Education Integrating Science, Mathematics, and Computing (CEISMC)
Jeremy Lingle, College of Science/ Center for Education Integrating Science, Mathematics, and Computing (CEISMC)
Bonnie Harris, College of Science/ Center for Education Integrating Science, Mathematics, and Computing (CEISMC)

Research suggests that the quality of the teaching workforce is the single most important factor in predicting student achievement (Darling-Hammond & Ball, 1997). “Quality” has many dimensions, however. Effective teachers must have a solid knowledge of academic content, a high mastery of different pedagogical techniques, an understanding of student developmental issues and different ways of learning, and a strong sense of professionalism. In a commitment to providing first hand connections between classroom activities and real world applications, the Georgia Intern-Fellowships for Teachers (GIFT) initiated in 1991 by the Georgia Institute of Technology is a collaborative effort between industry and education. GIFT provides mathematics, science, and technology teachers in grades six through twelve (students between 12 and 17 years old) ‘real life’ experiences in the applications of those disciplines. Over time, GIFT has placed 1,515 teachers into summer internship positions of 4-7 weeks in corporate and university research laboratory settings. The primary goal of the study is to examine the impact of the GIFT program on teachers’ practice. Through this study, we will work to uncover patterns and develop themes across cases (Yin, 1994) that capture prior experiences, knowledge, and beliefs brought by the teachers into the program, and the interaction of these factors with their learning and teaching experiences. Specifically, we examined:

1. What are the common inquiry-based instruction beliefs among GIFT teachers?
2. How did the GIFT program impact teachers’ beliefs and enactment of inquiry-based instruction?
3. What impacts did the real-world experiences that the teachers experienced through their participation in the GIFT Summer program have upon their professional development?
4. What aspects of the mentor relationship were related to the impacts of the GIFT experience?

This study documents GIFT program impacts on teachers. It shows that science teachers more readily incorporate elements of inquiry based learning into efforts to engage students with the content after participating in the program. Additionally, science teachers’ practice regarding inquiry-based instruction is able to come more into line with their beliefs about its importance. Lastly, it was discovered that the mentorship experience is significantly related to the teachers’ increased commitment to the teaching. Further, the program was effective in providing teachers with additional skills, which allowed them to be more effective instructors in the classroom. The opportunity to participate in a community of educators and the experience of actually being mentored provided them insight into the role of teaching in STEM disciplines.
Teaching Epistemology to Train Engaged Mechanical Modelers

Chloé Arson, College of Engineering/School of Civil & Environmental Engineering

“What know a priori of things is what we put in them ourselves”, Kant wrote (Critique of Pure Reason, Preface of the Second Edition, 1787). The scientific debate cannot emerge before the object (“things”) under study (“that we know”) is defined (“put by ourselves”). For instance, damage is an abstract concept, associated to the ideas of degradation, decrease of performance or loss of reliability. Damage prediction in geomaterials and composites relies on the field variables chosen to describe the anticipated degradation. Is there really a consensus on what needs to be observed? What should be the thinking framework of the mechanical modeler of the twenty-first century? Modeling is necessarily a dynamic thinking process, well described by Claude Bernards’ OHERIC approach: Observation-Hypothesis-Experimentation-Interpretation-Conclusion. The goal of this project is to create a “school of thinking” across engineering disciplines, and to initiate a new research stream on the cognitive process involved in modeling. Engineering graduate students will be taught a philosophy of modeling applied to material behavior prediction. The main objectives are to:

1) Prepare students to make a difference by publishing original work. The increasing number of engineering journals raises the question of research quality. Lectures will include history of science (including case studies that could be presented by Professors of different schools of engineering), and epistemology. Topics will include: the definition of a physics theory (P. Duhem), the principles of falsification (K. Popper), the theory of scientific revolutions (T.S. Kuhn) and archéology of knowledge (G. Bachelard, M. Foucault). The objective is to train students to be critical of the approach adopted in engineering papers, and to improve their dialectic skills.

2) Train students to be efficient and confident modelers. Models are based on postulates. The process of verification itself is based on assumptions. Therefore the modeling researcher is continuously put in a situation of doubt. When stopping doubting? Workshop sessions will have students work in group on their own research project, to help them frame their own modeling approach and get ownership of both assumptions and conclusions.

3) Engage students in the scientific debate. Oral presentations will prepare the students to defend their research project. In addition, collaborative work with the Center for Ethics and Technology at GeorgiaTech will expose the students to ethics in science.

*This work is supported by a grant entitled “Learning and Cognition.”
Physics Teaching Tools on Mobile Touchscreen Devices*

Prof. David R. Ballantyne, College of Science/School of Physics

We describe our recent NSF CAREER submission in which we propose a five year study to develop two touchscreen physics simulations for use on tablets and smartphones, using a research-based development procedure to assess their quality and effectiveness. The two applications (or, `apps') will be focused on increasing students’ understanding and intuition of charges, electric and magnetic fields, and the concept of superposition, topics well known to cause difficulty in introductory electricity and magnetism (E&M) classes. Tablets are the ideal devices for the next generation of physics education tools. First, the touchscreen allows students to interact with the application to help develop physics intuition. Second, they are portable so that students can use the application at any time and any location (not just in the lecture hall). Third, these devices are becoming increasingly common, with a recent survey by the Pearson Foundation showing the number of college students with touchscreen tablets has more than tripled in the last year. To illustrate the idea, and to demonstrate that it can be done, we have developed a proof-of-concept app for both Android phones and tablets that is currently available for download from the Android Marketplace. The development was done with a team of 5 GT computer science majors in Fall 2011 who developed the app as a project for the course CS 4911 Design Capstone Project. The app contains two simulations for use in introductory E&M courses. We will illustrate (and, hopefully, demonstrate) the proof-of-concept app, and describe the development plan if the proposal is successful.

*This work has been submitted as part of a CAREER grant proposal (currently under review).
Technology-Focused Professional Development in Georgia Schools:  
A Decade Retrospective

Therese Boston, GTRI/Foundations for the Future  
Jessica Pater, GTRI/Foundations for the Future

The Explorers Guild, the professional development component of the Foundations for the Future (F3) Program, focuses on developing long-term relationships with and among Georgia educators and administrators. Over the past 10 years, the workshops have offered participants the opportunity to learn new technology tools, cutting edge applications to assist in the classroom, and strategies for increasing their funding base. This poster will look at trends in technology topics as well as outcomes of sessions.
A Real-Time Model to Assess Student Engagement for Intelligent Educational Agents

LaVonda N. Brown, College of Engineering/School of Electrical and Computer Engineering
Ayanna M. Howard, College of Engineering/School of Electrical and Computer Engineering

Adaptive learning is an educational method that utilizes computers as an interactive teaching device. Intelligent tutoring systems, or educational agents, use adaptive learning techniques to adapt to each student’s needs and learning styles in order to individualize learning. Effective educational agents should accomplish two essential goals during the learning process – 1) monitor engagement of the student during the interaction and 2) apply behavioral strategies to maintain the student’s attention when engagement decreases. In this paper, we focus on the first objective of monitoring student engagement. Most educational agents do not monitor engagement explicitly, but rather assume engagement and adapt their interaction based on the student’s responses to questions and tasks. A few advanced methods have begun to incorporate models of engagement through vision-based algorithms that assess behavioral cues such as eye gaze, head pose, gestures, and facial expressions. Unfortunately, these methods require a heavy computation load, memory/storage constraints, and high power consumption. In addition, these behavioral cues do not correlate well with achievement of high-cognitive tasks, as we will discuss in this paper. As an alternative, our proposed model of engagement uses physical events, such as keyboard and mouse events. This approach requires fewer resources and lower power consumption, which is also ideally suited for mobile educational agents such as handheld tablets and robotic platforms.

In this paper, we discuss our engagement model which uses techniques that determine behavioral user state and correlate these findings to mouse and keyboard events. In particular, we observe three event processes: total time required to answer a question; accuracy of responses; and proper function executions. We evaluate the correctness of our model based on an investigation involving a middle-school after-school program in which a 15-question math exam that increased in cognitive difficulty is used for assessment. The first 5 questions of the exam are categorized as simple 1-step problems; the next 5 questions require multiple steps; the last 5 questions are categorized as very difficult (i.e. requiring a high-cognitive load). Eye gaze and head pose techniques are referenced for the baseline metric of engagement. We then conclude the investigation with a survey to gather the subject’s perspective of their mental state throughout the exam.

We found that our model of engagement is comparable to the eye gaze and head pose techniques. When high-level cognitive thinking is required, our model is more accurate than the eye gaze and head pose techniques due to the use of outside variables for assistance and non-focused gazes during questions requiring deep thought. The large time delay associated with the lack of eye contact between the student and the computer screen causes the aforementioned algorithms to incorrectly declare the subjects as being disengaged. Furthermore, speed and validity of responses can help to determine how well the student understands the material, and this is confirmed through the survey responses and video observations. This additional information will be used in the future to better integrate instructional scaffolding and adaptation with the educational agent.
NanoThink! – The Fusion of Science and Art at the Nanoscale*

**Baratunde Cola**, College of Engineering/Woodruff School of Mechanical Engineering  
**Jamila Cola**, College of Science/Center for Education Integration Science, Mathematics, and Computing  
**Renee Gaither**, Tucker High School, Tucker Georgia  
**Kelly Voss**, Tucker High School, Tucker Georgia

The Georgia Institute of Technology NanoEngineered Systems and Transport (NEST) Lab in collaboration with the Georgia Tech Center for Education Integrating Science Mathematics and Computing (CEISMC) has been working with science and art teachers at Tucker High School in DeKalb County Georgia to establish a program that interfaces Nanoscience and Art education. The poster will provide information about the ongoing program and how others could develop similar programs. The scope of the project is to use compost piles at the school to allow the environmental science students to explore energy generation in the compost and its possible conversion to electricity. Both the science and art classes are examining the composted material with optical and scanning electron microscopes to see the breakdown of materials at different scales. An SEM (Hitachi TM3000) is being used to allow the students to visualize and explore the nanostructure of materials that play a role in processes to convert heat energy to electricity. The art students will visually interpret the nanoscale images through various media. They will learn about ways to reduce our impact on the environment. The science students will monitor the compost pile’s energy production but will also be introduced (by the art teacher) to the meanings of colors and color clichés and they will be asked to think about the color(s) of energy. They too will create visualizations from the SEM images. SEM images and art work will be shared through the poster.

*This work is being completed as part of an CAREER grant.*
University- High School Partnerships Promote Integrated Science and Art Curriculum

Jamila Cola, College of Science/Center for Education Integrating Science, Mathematics, and Computing
Renee Gaither, Tucker High School
Kelly Voss, Tucker High School
Claire Zimmerman, Dunwoody High School
Janetta Greenwood, Dunwoody High School
Eric Gaucher, College of Science/ School of Biology
Loren Dean Williams, College of Science/ School of Chemistry and Biochemistry
Baratunde Cola, College of Engineering/ School of Mechanical Engineering and Materials Science

Collaborations between Georgia Tech and high school art and science teachers have provided high school educators with the exposure and skills necessary to prepare our future workforce and to foster student interest in science and engineering. In an effort to promote science and engineering literacy, art and science teachers were invited to participate in the Georgia Intern Fellowship for Teachers (GIFT) summer research program as a team. Teaming is vital to sharing ideas and implementing integrated lessons throughout the school year. The teachers worked with faculty and graduate students in the Schools of Mechanical Engineering, Biology, and Chemistry and Biochemistry at Georgia Tech to develop lesson plans that integrate science and engineering with art. The art pieces produced by students and teachers will be displayed and novel lesson plans on nanotechnology, the origins of life and harvesting waste heat from a compost pile will be discussed.
Astrobiology Summer Enrichment Program for High School Students*

Jamila Cola, College of Science/Center for Education Integrating Science, Mathematics, and Computing
Loren Dean Williams, College of Science/School of Chemistry and Biochemistry
Janetta Greenwood, Dunwoody High School
Eric Gaucher, College of Science, School of Biology
Ryan N. Randall, College of Science, School of Biology
Terry Snell, College of Science/ School of Biology.

The Georgia Tech Center for Ribosomal Origins and Evolution, a center funded by the NASA Astrobiology Institute, developed a week-long summer enrichment program for high school students titled, “Life on the Edge: Astrobiology.” High school educators, two undergraduate students interested in teaching careers, and faculty in the Schools of Biology, and Chemistry and Biochemistry at Georgia Tech developed the content for the program. Twenty high school students from the Atlanta metro area were introduced to hands-on activities that explored extremophiles and techniques such as genomic DNA purification, gel electrophoresis, and Polymerase Chain Reaction (PCR). The details of the Astrobiology Summer Learning Program as well as qualitative survey results will be discussed.

* This work is part of a grant from the NASA Astrobiology Institute.
Stakeholder Requirements in the Context of Aerospace Vehicle Systems Design: Implications for Engineering Education and Industry

Alexandra Coso, College of Engineering/School of Aerospace Engineering
Dr. Amy Pritchett, College of Engineering/School of Aerospace Engineering

The design of an aerospace vehicle system is a complex integration process, driven by technological needs, mission needs, cost, schedule, and the state of the industry. Whether an aircraft, an unmanned air vehicle, or a spacecraft, it is important to recognize that the resulting product will be a technology used to meet specific human needs. Satisfying the needs of all stakeholders, including both users and non-users, is a complicated challenge for designers and engineers, and stakeholder requirements are, at times, neglected and/or design decisions are made without considering the operational context of the vehicle system. These decisions can have significant impacts on stakeholders’ overall satisfaction with the design, life-cycle costs, and safety. Given the quantity and variety of stakeholders affected by the design and operation of an aerospace vehicle system, it is critical to examine how to better incorporate stakeholder requirements earlier and throughout the design process. The intent of this research is to (1) understand the gap between what is needed in industry to respond to this issue and what is taught in the aerospace engineering design curriculum and (2) design and implement an educational intervention to address this gap and improve the ability of students to take into account stakeholder requirements.

The proposed research aims to integrate approaches to design that focus on stakeholder considerations into the aerospace engineering design curricula of a senior-level fixed wing design course. The first phase of the research will support the development of an educational intervention by identifying how stakeholder considerations are taken into account in (1) the practice of aerospace engineering design through the use of an industry-case study and (2) the aerospace engineering design curricula through the distribution of an in-class evaluation. The results of Phase I will influence not only the content of the intervention, but also the learning theory and pedagogical techniques underlying its design. The second phase of the research is the design of the educational intervention. Following the implementation of the intervention, its impact will be assessed through the examination of student capstone projects and an in-class evaluation.

The work outlined in this proposal will serve as a starting point for future research in pedagogical techniques and assessment methods for integrating stakeholder requirements into technology-focused capstone design courses. The results will inform the vehicle design education of students and engineers from other disciplines, as stakeholder considerations can be integrated into the design process for any complex system.
Connecting the Environment to the Schoolhouse – A Look at Distributed Sensor Projects in the Classroom

Jim Demmers, GTRI/Foundations for the Future

Over the past several years the Foundations for the Future Program has collaborated with Georgia schools to create projects that integrate distributed environmental sensors. This poster will look at several projects (e.g. Sea Maven and Small Fry to Go), the technologies employed, their project design, and their impacts on science efficacy and classroom instruction.
**Promoting STEM Engagement and Global Awareness of High School Mathematics Students through Engineering**

Doug Edwards, Center for Education Integrating Science Mathematics, and Computing  
Jessica Gale, Center for Education Integrating Science, Mathematics and, and Computing  
Jeremy Lingle, Center for Education Integrating Science, Mathematics, and Computing

This poster will describe the development and implementation of an innovative high school mathematics course that utilizes engineering as a context to engage high school students in STEM disciplines and to increase students’ global awareness. Math4-OR (Mathematics of Industry and Government [MIG]), which is a fourth year applied mathematics course offered in the state of Georgia, focuses on industrial engineering and operations research concepts. Supported by Georgia’s Race to the Top grant, CEISMC is currently working with one local high school to center the context of the MIG curriculum around the authentic engineering task of providing electricity for rural South Africans. The high school implementing the project serves a population of predominantly low-income, African American students who are frequently underrepresented in STEM disciplines. The cohort of student participants, which is jointly enrolled in the MIG class and an engineering technology class, is in the process of constructing solar panels that will be utilized to increase access to electricity for a rural school in Evaton, South Africa. The construction of the solar panels takes place in the engineering technology class and serves as a context for students’ mathematics learning in the MIG classroom. As part of their course work, students also correspond via Skype and blogs with South African students who are undertaking similar engineering projects. The poster will describe the structure of this interdisciplinary Mathematics-Engineering project and highlight preliminary findings of the project evaluation. Specifically, we will describe survey and observation data pertaining to participating students’ global awareness, motivation, and engagement in STEM disciplines.

*This work is funded by Georgia’s Race to the Top Grant.*
Design of a Decision Support System to Improve Academic Major Selection in the College of Engineering

Karen M. Feigh, College of Engineering/School of Aerospace Engineering

Most students will choose an academic major intuitively, based on little quantifiable information. Many may have never met someone with the credentials they seek and may be relying solely on the portrayals available on television and movies, or cultural beliefs regarding pay or prestige. Additionally, while information is available on different majors, making sense of this information in terms that are relevant to the student’s life situation and goals may be difficult. Further, the number of possible options of academic major in combination with minors and certificates, study abroad programs, internships, etc. can seem overwhelming. A DSS may be useful for this domain of choosing one’s field of study.

Helping students to choose a major is a well-established challenge. Almost every university has a webpage dedicated to advising students how to choose, and many have dedicated seminars devoted to the same topic. Unfortunately, with few exceptions, such as Li et al. (2009), few studies have investigated the basis for choice of major in a STEM field beyond the ascriptive characteristics of gender and race. Notable exceptions have illustrated that a significant proportion of students decide on a major only after arriving on campus (George, 1985). Factors which have been found to influence the choice of major include perceived aptitude for the discipline, excitement generated by research experiences, the importance of the field to solving large societal problems, parental and societal expectations, expected earnings and other labor market influences (George, 1985; Montmarquette et al., 2002), and “fit disconnect” between images of particular engineering fields obtained from entry-level courses (Walden and Foor, 2008) and the realities of the profession. This research aims to help students choose an engineering major by designing a web-based support system to address many of these issues.

The support system will be imbedded into a website which will be publically viewable and advertised to all incoming Georgia Tech students. The support system will seek to utilize information gleaned from the in-house longitudinal survey to supplement information available in the literature. One of the primary goals will be to present information in a manner which is relevant to the student’s life and supports the decision strategies used by the students. To that end, instead of presenting a set of quantitative data, to help students make what is inherently a personal choice, this DSS will center on a collection of short video clips which are searchable. In contrast to other websites which encourage the pursuit of engineering careers using video clips of practicing engineers, the video clips created in this program will be organized into short 1-3min snippets in which the featured engineer answers a single question. Videos will record a single engineer responding a series of prompts – which will be tailored based on the survey results.
Understanding Academic Major Selection in the College of Engineering: Preliminary Results from a Longitudinal Survey

Karen M Feigh, College of Engineering/School of Aerospace Engineering
John Leonard, College of Engineering

Helping students to choose a major is a well-established challenge. Almost every university has a webpage dedicated to advising students how to choose, and many have dedicated seminars devoted to the same topic. Unfortunately, with few exceptions, such as Li et al. (2009), few studies have investigated the basis for choice of major in a STEM field beyond the ascriptive characteristics of gender and race. Notable exceptions have illustrated that a significant proportion of students decide on a major only after arriving on campus (George, 1985). Factors which have been found to influence the choice of major include perceived aptitude for the discipline, excitement generated by research experiences, the importance of the field to solving large societal problems, parental and societal expectations, expected earnings and other labor market influences (George, 1985; Montmarquette et al., 2002), and “fit disconnect” between images of particular engineering fields obtained from entry-level courses (Walden and Foor, 2008) and the realities of the profession. This research aims to understand why students choose an engineering major by and to ultimately improve their likelihood of choosing the “correct” major early in their academic career.

The research focuses on a longitudinal study of why Georgia Tech engineering students change majors. The purpose of the survey instrument is to gain a more complete understanding of the reasons that engineering students choose an academic major, change majors, and the impact that changing majors has on the student’s academic progress. Work on this portion of the research began in November 2011, with the first survey having been issued in July 2012. Four distinct groups were identified: students who changed majors within engineering, out of engineering, into engineering and who did not change majors. The survey instrument is tailored to the unique needs of each group. For example, students who never changed majors are asked instead about if they ever considered changing majors, and what factors influenced their decision not to do so. The research plan is to issue the survey annually and to use the data to understand what information sources students currently use and what information is lacking. Furthermore, the survey seeks to identify influences beyond access to information which impact choice of major or decision to change major.
**TESSAL: Portable Laboratories Integrated into Lecture-Based Courses**

**Bonnie Ferri**, College of Engineering/School of Electrical and Computer Engineering  
**Jill Auerbach**, College of Engineering/School of Electrical and Computer Engineering  
**Aldo Ferri**, College of Engineering/Woodruff School of Mechanical Engineering  
**Jennifer Michaels**, College of Engineering/School of Electrical and Computer Engineering  
**Douglas Williams**, College of Engineering/School of Electrical and Computer Engineering

Hands-on activities are an essential part of the learning experience for STEM students to demonstrate theoretical concepts in practice and to connect students with the experimental component of our STEM disciplines. Historically, these activities were relegated to experiments conducted in centralized laboratories utilizing expensive equipment and requiring extensive support infrastructure. Portable, low-cost, experimental platforms that utilize student resources such as laptops and other mobile devices allow students to conduct the lab at desks in a traditional classroom or in a dorm room. These types of experiments allow for a new pedagogical model that promotes a more complete integration of theory and laboratory experience, especially when used for hands-on activities in lecture-based courses.

Two grants funded by NSF, through the CCLI and TUES programs, develop lab modules and procedures for implementing these portable labs in lecture-based courses. The laboratory modules contain the following components: laboratory procedures for students, tutorial videos on the experiment, tutorials on fundamental concepts, and an online test that gives sample problems that would appear on exams in the lecture-based course. The goal was to integrate the modules closely with lecture material. The initial grant, which started in 2006, centered in ECE under the TESSAL Center with some use of modules in ME classes. Modules associated with this center have been used by 31 instructors and approximately 2700 students and 700 K-12 students in outreach activities. Assessment methods included student surveys, student performance on class exams, and concept inventory tests. Positive results in this study prompted the integration of portable labs into five core lecture-based courses in the new ECE curriculum. The current NSF grant is collaborative with RPI and Virginia Tech and aims to expand this hands-on learning pedagogy into other STEM disciplines and other types of schools such as community colleges.

*This work is supported by NSF CCLI and TUES grants.*
Finding Points of Intersection on Auditory Graphs

Hannah Fletcher, College of Sciences/School of Psychology

Auditory graphs can be very useful, especially in mathematics education for the visually impaired. One standard that is covered in Algebra I courses is the ability of the student to find a point of intersection between a linear and a quadratic equation. The current study tested several stimulus types (monophonic pure tones, stereo separated pure tones, monophonic band-limited noise, and stereo separated band-limited noise) to determine which factors enabled participants to most successfully find points of intersection on an auditory graph. The researchers found that pure tones were better than noise for displaying these points of intersection, and that stereo separation versus monophonic sound did not seem to have an effect for either sound stimulus. When creating auditory graphs, designers should be informed by research like this in order to make the best design decisions possible for their users, either visually impaired or not.
EarSketch: Computational Remixing and Sharing as a Tool to Drive Engagement and Interest in Computing*

Jason Freeman, College of Architecture/School of Music
Brian Magerko, Ivan Allen College/School of Literature, Media, and Communication

EarSketch, our approach to engaging students in computing principles through collaborative computational music composition and remixing, consists of an integrated curriculum, software toolset, and social media website. The EarSketch curriculum targets introductory high school computing education, with a particular focus on groups traditionally under-represented in computer science. The software toolset enables students to create music by manipulating loops, composing beats, and applying effects with Python code. The social media website invites students to upload their music and source code, view other students’ work, and create derivative musical remixes from other students’ code. EarSketch is built on top of Reaper, an intuitive digital audio workstation (DAW) program comparable to those used in professional recording studios. It is extremely practical for educational settings due to its low cost, cross-platform compatibility, and low processor and memory utilization.

EarSketch is designed to enable student creativity, to enhance collaboration, and to leverage cultural relevance. This focus has created unique advantages for our approach to computing education. First, EarSketch leverages musical remixing as it relates to popular musical forms, such as hip hop, in an attempt to connect to students in a culturally relevant fashion that spans gender, ethnicity, and socioeconomic status. It does so by explicitly connecting the learning environment to popular music production software, by drawing from industry practice in the features it supports, and by visualizing computational output within standard studio paradigms. It also focuses on the level of beats, loops, and effects more than individual notes, enabling students with no background in music theory or composition to begin creating personally relevant music immediately, with a focus on higher-level musical concepts such as formal organization, texture, and mixing. Second, student use of the social media site allows a tight coupling between code sharing / reuse and the musical practice of remixing. Students can grab code snippets from other projects and directly inject them into their own work, modifying them to fit their idiosyncratic musical ideas. Third, unlike more graphically-oriented environments such as Scratch, EarSketch builds on professional development techniques using an industry-relevant, text-based programming language (Python), giving them concrete skills directly applicable to further study.

EarSketch was piloted at Georgia Tech’s Institute for Computing Education in a 2012 summer camp, with positive evaluation results with respect to both content knowledge and attitudes towards computing and creativity. In January 2013, it will be tested as part of an academic computing course with 75 high school students at Lanier High School in Gwinett County.

*This work is supported by NSF CE21.
From STEM to STEAM:
Art and Design Activities Fueling K-12 STEM Learning*

Ann Gerondelis, College of Architecture

Can the hands-on activities of design learning support K-12 student engagement with STEM subjects? This question is at the core of a partnership between Drew Charter School and Georgia Tech’s College of Architecture and CEISMC. Together GT faculty Donna Whiting, Ann Gerondelis and Raja Schaar are working with middle school faculty and administrators to explore possibilities over a 3-year period.

Calls for incorporating the Arts into STEM learning are increasingly expanding. They can be heard in our neighborhood, where Atlanta’s Drew Charter School was named the 2012 Georgia Charter School of the Year with its strong curricular emphasis on STEAM. They can be heard in our government, where House Resolution 319 calls for adding art and design into Federal programs that target the STEM fields encourages innovation and economic growth in the United States. They can be heard from Elmo on Sesame Street, with a new seasonal focus updating their prior emphasis on STEM learning to STEAM! And of course, they can be heard in the College of Architecture, where innovative design thinking is fueled by close inquiry and research, articulate representations, and vibrant imaginations.

Faculty from the College of Architecture’s Common First Year Design Studio are working with Drew Charter School administrators and faculty to design and implement applied thematic projects that A) promote students’ engagement with STEM subjects as well as B) introduce them to the fields of architecture and industrial design. Currently in its initial phases, the faculty/administrator teams have been working

- to make STEAM curricular connections, mapping new common core standards onto design thinking and making skills

- to expand design literacy through CoA faculty-led conversational tours of Atlanta design facilities with Drew middle school faculty

- to workshop small design/analysis exercises and strategize pilot projects in a broad range of subject areas

- and to develop strategies for building on successes and expanding their reach.

* This work is part of the Georgia Tech – Drew Charter School Race To The Top STEM Innovation Partnership, Connections in Architecture and Industrial Design.
Collaborative Learning within the NASA Electronic Professional Development Network*

Sabrina Grossman, College of Sciences/CEISMC
Meltem Alemdar, College of Sciences/CEISMC
Storm Robinson, College of Sciences/CEISMC
Jeff Rosen, College of Sciences/CEISMC
Mike Ryan, College of Sciences/CEISMC
Marion Usselman, College of Sciences/CEISMC

In 2009, Georgia Tech received an award from NASA to develop online professional development (PD) courses for STEM teachers. The electronic Professional Development Network (ePDN) is a collaboration between Georgia Tech Professional Education and the Center for Education Integrating Science, Mathematics and Computing (CEISMC) and offers four different certificate series: a) Project-Based Inquiry Learning, b) Robotics, c) Statistics, and d) Technology Integration. Each certificate series consists of four courses totaling 65-75 hours, and successful participants are awarded Continuing Education Units. Courses are designed using best practices that occur in effective face-to-face PD sessions and incorporate active learning that promotes interaction, discourse and reflection. The courses are asynchronous, but they require weekly participation, an estimated 5 hours/week time commitment, and they are actively facilitated by instructors. They incorporate constructivist pedagogy (inquiry learning, student centered learning, and collaborative learning environments) and offer types of support critical to effective PD. ePDN courses were developed using T-Square, and now run on the HELIX Learning Management System, which is an upgraded Moodle platform. This poster will focus on two of our certificates: Project-Based Inquiry Learning and Robotics and will describe the collaborative nature of these courses along with the impact of teacher PD.

- **Project-Based Inquiry Learning (PBIL)** educates teachers on developing skills in designing and using PBIL to enhance conceptual understanding, critical thinking, and scientific reasoning in a standards-based classroom. Participants experience PBIL projects firsthand, learn PBIL curriculum design strategies, and design and implement a PBIL unit for use in their classroom.

- **Using Robotics to Enhance STEM Learning** focuses on educating K-12 teachers in using Lego Mindstorm NXT kits in their math, science, and technology classes and in extracurricular activities. Teachers learn basic robot building instructions and how to program basic robot behaviors using motors and rotation, sound, light, and touch sensors.

Collaboration between participants plays a major role in the ePDN courses and is accomplished through a suite of asynchronous and synchronous tools including discussion forums, blogs, wikis, twitter, resource collaboratives, and chat rooms. Participants use these tools to actively collaborate, connect, and create with one another. Our poster will focus on the integral role that this collaboration plays in promoting student learning within the ePDN courses.

The principal research method employed in this study is to develop aggregate narratives for each course that describe the effectiveness of the ePDN model from the perspective of each course participant. A variety of data sources are used in this study: participants’ weekly feedback reports, forum discussions, and end-of-course evaluations. Throughout the ePDN courses, our approach was to encourage students to engage in discussion, and develop an online community. Data on actual participation and collaboration in online discussions were collected throughout the courses. Participants felt that the networking and collaboration with the members of the class was “invaluable” and they learned from each other by participating in critical discussions. Further, they felt that collaboration and provided tools for networking (such as blogging) contributed to their learning.

*This work is part of a NASA Education grant.*
Strengthening the Pipeline of Latino K-12 Students into Post-Secondary STEM Education: Results from GoSTEM’s Pilot Study*

Diley Hernandez, Office of the Provost/Center for the Enhancement of Teaching and Learning
Cher Hendricks, College of Science/Center for Education Integrating Science, Mathematics, and Computing
Donna Llewellyn, Office of the Provost/Center for the Enhancement of Teaching and Learning
Marion Usselman, College of Science/Center for Education Integrating Science, Mathematics, and Computing
Analia Rao, Office of the Provost/Center for the Enhancement of Teaching and Learning

This poster showcases the evaluation results for GoSTEM, a program to strengthen the pipeline of Latino students into post-secondary STEM education. The project constitutes collaboration between Georgia Tech and Gwinnett County Public Schools.

As part of our first year program, we collected data from several sources about three program initiatives: (1) Pathways to College, a college preparation mentoring program; (2) Graduate Teaching Fellows (GTF), a teacher-student partnership initiative; and (3) a Parental Involvement Program. The primary questions guiding our evaluation for each program were:

1) What was the effect of the Pathways and GTF programs on student participants? What changes needed to take place in existing Pathways and GTF programs to be adapted to a Latino K-12 population?

2) What were the students’, teachers’, and mentors’/fellows’ perceptions and attitudes about the programs?

3) What were the needs of parents in the school cluster for getting their children to college? What career preferences did parents have for their children? What were parent attitudes about STEM careers?

Data were collected from students, teachers, mentors, fellows, and parents using a variety of methodological approaches (quantitative and qualitative) and instruments (surveys, focus groups, and interviews) in order to achieve triangulation.

Results will include a description of the major themes that emerged from our data and an analysis of student’s perceptions of school, student’s cultural identity, motivations, expectations and habits, as well as STEM career awareness and college goals.

* This work is supported by GoSTEM.
Teaching and Facilitating Modeling and Investigation of Complex Systems in Middle School Classrooms*

David Joyner, College of Computing / School of Interactive Computing
David Majerich, College of Computing / School of Interactive Computing
Ashok Goel, College of Computing / School of Interactive Computing

In order to tackle STEM problems in the modern world, individuals must possess a strong ability to reason about and understand complex systems in a practical and useful way. Past research has indicated that experts and novices possess fundamentally different kinds or structures, rather than just different levels, of understanding of complex systems. Therefore, to adequately prepare students to address problems pertaining to complex systems, it is important to help them acquire an understanding of complex systems that better resembles the structure and kind of understanding employed by experts. This challenge exists at two levels of abstraction: it is important to help students obtain expert-like understanding of individual complex systems, and it is also important to help students develop the metacognitive skills necessary to make sense of new complex systems that they encounter in new domains. We have approached this problem from two angles. First, we have created an interactive environment (MILA, for Modeling & Inquiry Learning Application) in which students may investigate complex systems in a manner similar to that of scientists and engineers; by providing a context in which students can personally experience the system and construct their own understanding of it, we believe that students will achieve a deeper and more engaging understanding of the system, as well as a more authentic understanding of and comfort with the processes of modeling and inquiry. These skills do not develop on their own, though, and so secondly, we have embedded metacognitive teaching agents (MeTA, for Metacognitive Tutoring Architecture) into the interactive environment. These teaching agents provide situated guidance to the students, engaging in demonstration and error correction as well as encouraging reflective practice and self-regulated learning.

*This work is supported by an NSF IES grant.*
In recent years, the nature of education has been undergoing a precipitous change largely due to technological advances enabling ubiquitous access to information, computation, and mobility. Today’s learners seek personalized education where knowledge can be targeted to a specific interest or skill and administered at the learner’s corresponding difficulty level, schedule, and pace. Teachers have an additional need to timely monitoring student progress and decisively assessing student comprehension. Recent research on learning has demonstrated the benefits of providing students with extensive learning opportunities through sustained concept-based practice and repeated testing. In fact, the act of successive retrieval practice has been shown to contribute to greater conceptualization and development of meta-cognitive skills than by simply studying.

Students build their understanding by gathering relevant pieces of information and form associations among them to construct an internal representation of the knowledge domain. These conceptual structures, often referred to as concept maps, dictate how knowledge is organized and ultimately accessed during problem solving activity. The difference between novice learners and experts in a given field is based on how knowledge is organization and utilized. Experts organize knowledge by chunking information into hierarchical structures which allow them to effortlessly and efficiently access knowledge and search for a solution by pattern matching from the repertoire of existing known structures. During testing, student’s knowledge is impromptu assessed and prompted to recall, and if possible, to select and retrieve conceptually relevant information. Learners are forced to reason themselves about the problem and in the process reconstruct and consolidate knowledge which itself enhances learning.

We present a web-based concept-centered educational platform, called ITS, which has been deployed in the sophomore-level introductory Signal Processing (SP) course in the School of Electrical Engineering. ITS is a question and answer system whose goal is to assist students in SP concept discovery, organization, and testing. The system consists of over 1500 multiple-choice, matching, and calculated questions, each referencing a topic from the course textbook. In the student view, there are two interfaces: the “Practice” mode and the “Assignment” mode. The practice mode presents learners with a list of concepts and directs users to create a plan of study. Students can select a desired textbook topic or a specific concept which enables them to engage in self-directed study by solving concept-centered question which are anchored in and target these specific concepts. The “Assignment” mode consists of on-line set of problems which are grouped by textbook chapters and graded as part of student’s homework. The instructor view enables question authoring tools to create, clone, edit, publish, search, and share questions.

Over the past five semesters, ITS has been used by over 2000 students. On average, students attempted 91% of the available questions, and 82% of the students managed to earn a full-credit. At the moment, ITS is a testing platform with data collection capabilities. However, we are working on extending its functionalities to infer from student-activities a “student state” in order to introduce more effective learning opportunities.

* Supported in part by the National Science Foundation Award No. 1041343
"Collaborative Research: CI-Team Implementation Project: The Signal Processing Education Network".
Increasing Student Engagement in Biology with an Authentic Creative Writing Assignment

Jennifer Leavey, College of Sciences/School of Biology

Students studying science, technology, engineering and math (STEM) scored significantly lower than their non-STEM peers in Integrative and Reflective Learning and Higher-Order Learning on the 2005 and 2008 NSSE. Strategies to address this deficiency are varied, but social networks such as interactive blogs, Facebook and twitter have been shown to be effective in increasing student confidence in academic performance, peer interaction, semester grade point averages and student-faculty engagement in college settings, and the use of engaging websites in class has been shown to increase student understanding of concepts. Here, we have designed an in-class activity to challenge Georgia Tech students to think and communicate creatively about science (biology specifically) by creating an article and illustration for the new online magazine www.chargedmagazine.org. This magazine is targeted toward teenagers and young adults aged 16-24. Student opinion of the assignment was mixed and although students generally had favorable opinions about thinking creatively about science, one student commented that biology students were not, "naturally creative thinkers." Some students commented that making information accessible to a general audience was a good idea, suggesting that the service-learning aspect of the assignment helped to engage them. Other student feedback will help create a more effective assignment in its next iteration.
Exploring Gender Differences in BMED Changes in Major

John D. Leonard II, College of Engineering

This analysis explores BMED students changing majors over a three year period. Our sample consists of 2,045 unique students enrolled for at least one semester in BMED, of which 99 students (4.8%) changed majors into BMED from other majors on campus and 468 students (22.9%) changed out of BMED to other majors on campus. Overall, we observed women leaving BMED at rates higher than men. Further we observed that women changed to non-ENGR and non-STEM majors at rates higher than men.

Introduction: This analysis explores students changing majors in and out of Biomedical Engineering (BMED) over a three year period. For this study we designate source or destination majors within engineering (i.e., transferring to or from another engineering major including aerospace, civil, chemical, electrical, industrial, mechanical, or materials science), other STEM colleges at the university (e.g., computing or sciences), and non-STEM colleges (e.g., liberal arts, management, or architecture.) With these designations we explore changes in major by gender, ethnicity.

Materials and Methods: A data set containing one record per student per term over a three year period across all majors at the university was constructed. In addition to a unique student identifier, each record contained attributes describing current activity of the student during the term including their current major. The data set is sorted first by student identifier then by term code. A student "changes major" when during any given term their current major is different from their previous major, that is, the major found in the previous record in the data set. Different questions can be posed and answered by inspecting prior, current and future majors, or by counting the number of changes in major over the study period. The data were prepared and analyzed using the R statistical package.

Results and Discussion: Our sample consists of 2,045 unique studente enrolled for at least one semester in BMED, of which 99 students (4.8%) changed majors into BMED from other majors on campus and 468 students (22.9%) changed out of BMED to other majors on campus. Of the 99 students transferring into BMED, 63% were men and 37% were women. Over the same period, 55% of the incoming freshmen were men and 45% were women. Of the 468 students transferring out of engineering 55% were men and 45% were women. Of the 257 men transferring out of BMED, 42% left engineering for other majors. Of the 211 women transferring out of BMED, 59% left engineering for other majors. Of the 468 students changing out of BMED, 50% changed to other majors in engineering, 30% changed to other STEM majors, and 20% changed to non-STEM related majors. The top five destinations include ISYE (engr), ME (engr), BIOL (stem), MGT (non-stem) and CHBE (engr.) The top five destination majors for men include ISYE (engr), ME (engr), CHBE (engr), ECE (engr) and MGT (non.stem). The top five destination majors for women include BIOL (stem), ISYE (engr), MGT (non.stem), CHEM (stem), and ME (engr).

Conclusions: Overall, we observe women leaving BMED at rates higher than men. Further we observe women change to non-ENGR and non-STEM majors at rates higher than men.
Analyzing K-12 Education as a Complex System*

Donna Llewellyn, Office of the Provost/Learning Excellence/CETL
Marion Usselman, College of Sciences/CEISMC
Douglas Edwards, College of Sciences/CEISMC

Schools and school districts are complex, dynamic systems affected by a number of factors specific to the environment. Educational researchers have long studied school reform and the issues of what facilitates and hinders success in curricular and other interventions. Experts in educational policy and public policy also have studied the interaction of policies and practices of reform agendas within social and organizational contexts. Industrial engineering, which had its origins in studying manufacturing systems, is a field where researchers have made great contributions towards understanding complex systems including transportation systems, financial systems, health care, and even recently humanitarian support systems. However educational reform has so far not been systematically analyzed using a multidisciplinary systems approach that includes the tools of industrial engineering.

We are creating an innovative framework, which is both conceptual and theoretical and rooted within the field of industrial engineering, to examine barriers and enablers to school change and reform. The framework describes the system both in terms of actors and the attributes of those actors and will become the foundation for identifying a subset of combinations that converge to levels that allow for successful change in the system. This poster will describe the first step in creating this framework, namely identifying the actors within K-12 education and the attributes of these actors that are critical to educational change. It will also present a scale for describing these attributes.

* This work is supported by a NSF Math and Science Partnership grant.
The Effects of the Problem Solving Studio on Student Learning

David Majerich, College of Computing / School of Interactive Computing
Wendy Newstetter, College of Engineering/Department of Biomedical Engineering
Joseph M. Le Doux, College of Engineering/Department of Biomedical Engineering

Introduction: Our goal is to improve student learning in entry-level engineering courses. We believe students struggle, in part, because many of these courses are taught using traditional teaching methods in which the professor lectures to students in a large classroom. It is becoming increasingly recognized that students who are taught with traditional methods are not engaged due to a lack of human interaction, and often do not see the relevance of what they are asked to learn. In addition, students in traditional courses are usually required to work alone, which is in stark contrast to industry’s team-centered approach to solving problems. In response to these issues, we have developed a new model for classroom instruction called the problem-solving studio approach which we believe improves student motivation, conceptual understanding, and performance in an entry-level biomedical engineering course.

Approach: The problem-solving studio is a strategy used to create a learning environment where students work in teams and are actively engaged in solving problems. The four key aspects of this approach are 1) modeling, 2) coaching, 3) scaffolding, and 4) self-explanation. The professor and undergraduate teaching assistants (who are generally students that previously took the course and have a high level of expertise in the material) serve as coaches for the students. Teams are presented with problems to solve, which they solve on large pads of paper, which serves as a communal problem-solving space. The professor and teaching assistants roam about the room and when they see students struggling, or when students ask for help, they coach the students with questions (coaching) to help them navigate through the problem-solving process (scaffolding). When challenges arise that affects multiple students, the professor will give a “just-in-time lecture”, which often includes the professor modeling his or her expert problem-solving strategies (modeling). As teams solve the problem, one person “holds the pen”, writes on the large pad of paper, and explains herself to her teammate as her teammate practices coaching her with questions (self-explanation). Self-explanation improves learning in part because it encourages learners to draw inferences and to become aware of, and then to revise, any flawed conceptual understandings that they may have. To examine the effect of the problem-solving studio environment on learning and motivation, we conducted a quantitative study of 59 students enrolled in an entry-level biomedical engineering course entitled “Conservation principles in biomedical engineering”. Students completed three validated instruments at the beginning and end of the semester to examine their approaches to studying and learning, their level of academic motivation, and their understanding of fundamental concepts of mass and energy conservation. We are interested in determining what variables are most significant in determining student success in the course.
Topology Students Workshop*

Dan Margalit, College of Sciences/School of Mathematics

In the summer of 2012 I ran the inaugural Topology Students Workshop at Georgia Tech. The basic idea was to bring in graduate students from my particular area of mathematics and spend a week working on various aspects of professional development. There was an emphasis on recruiting students from underrepresented groups in mathematics, and we were very successful in this regard.

There are many facets to a being a successful mathematician, the foremost of which is doing mathematical research. But the other aspects are often overlooked by Ph.D. programs and become the downfall of many students. So the goal of the week was to have a crash course in these topics.

Besides having seminar talks by top researchers in the field, we held seminars on creating and delivering research presentations, writing grant proposals, finding careers in and out of academia, teaching effectively and efficiently, applying for jobs, attending conferences, using and creating mathematical software, and publishing, among other things. At the end of the week, many students gave twenty minute talks, and were video recorded and evaluated by all of the students in the room. By all accounts, the program was a great success. We had about sixty participants, four times as many as expected. Many of the students left with the feeling that they had a better understanding of what they needed to do to succeed and that they had greater control over their destiny by paying attention to the various non-mathematical aspects of their jobs that we discussed.

More information can be found at tsw.gatech.edu

*This work is supported by an NSF CAREER grant.*
Designing Materials to Promote Subgoal Learning in STEM Education

Lauren Margulieux, College of Sciences/School of Psychology
Richard Catrambone, College of Sciences/School of Psychology
Mark Guzdial, College of Computing/School of Interactive Computing

STEM education must be improved to prepare society for increasingly technical jobs. Because STEM domains tend to be highly procedural, specific worked examples, which demonstrate how to apply procedures to specific problems, and abstract instructional text, which define procedures for problem solving, are used to teach students to solve problems. Novices, however, have trouble distinguishing between the structural information (central to the solution) and superficial information (peripheral to the solution) in worked examples and often find instructional text too abstract. Subgoal labels group steps of worked examples into meaningful units to help learners focus on structural features in examples. The present research explores the effectiveness of subgoal labels in instructional materials to help novices learn STEM subjects. In the first two experiments, undergraduates who received subgoal-labeled worked examples performed better on novel programming tasks than undergraduates who received non-subgoal labeled worked examples. The third experiment, in progress, examines whether the intervention is effective for K-12 teachers using the same materials in an online format.

A fourth planned experiment explores the effect of subgoal-labeled text on problem-solving performance. Prior work has focused on subgoal labels in worked examples; the planned experiment explores using subgoal labels in instructional text. The hypothesis is that subgoal labels will help students to understand the subgoals of a domain better, organize new information more effectively, and facilitate integration of the text and examples. It is predicted that there will be an interaction between subgoal-labeled instructional text and subgoal-labeled worked examples. Specifically, it is predicted that subgoal-labeled instructional text, when paired with non-subgoal labeled worked examples, will not improve problem solving because students will not be able to apply the subgoals to problem solving without the additional guidance afforded by subgoal-labeled examples. Furthermore, when subgoal-labeled instruction text and subgoal-labeled worked examples are used in tandem, participants are expected to outperform all of the other groups because the double presentation of subgoal labels will help them understand and apply the subgoals more effectively than the other groups.

This set of experiments applies effective instructional design to STEM education and explores whether the effectiveness of subgoal labels can be increased by using them in instructional text. In the future, successful interventions could be tested in a variety of STEM subjects.
The Direct to Discovery: Increasing Science Efficacy of Students Through Distance Learning Approaches

Les Smee, GTRI/Foundations for the Future and OIT
Warren Matthews, GTRI/Foundations for the Future and OIT

The Direct to Discovery (D2D) program focuses on connecting K-12 classrooms with research labs on the Tech campus. The project is designed to address several important issues such as authenticating knowledge, supporting teachers teaching out-of-field, and developing digital content tied to standards. One of the over-arching goals is to increase science efficacy within students across Georgia. This poster will discuss progress to-date and next steps.
Becoming a Learner-Centered Teacher: Constructing & Evaluating a TA Development Program

Carol Subino Sullivan, Center for the Enhancement of Teaching and Learning
Cara Gormally, College of Sciences/School of Biology
Nadia Szeinbaum, College of Sciences
Tris Utschig, Center for the Enhancement of Teaching and Learning

Background & study context

In the U.S., the majority of introductory lab courses at major research universities are taught by teaching assistants (TAs), including at Georgia Tech. For example, the School of Biology employs ~50 TAs per semester, the vast majority (80%) of whom are assigned to introductory courses. Since completing a lab course is part of the core curriculum, TAs impact the education of every undergraduate at the Institute. In recent years, learner-centered approaches, such as inquiry-based teaching, have been implemented across the U.S. in response to calls for reform to university science, technology, engineering, and math (STEM) education to address declines in student interest and persistence in STEM disciplines. Consequently, preparing and supporting TAs to teach in innovative ways is urgent.

The Center for the Enhancement of Teaching & Learning CETL conducted a needs assessment in order to systematically redesign a course (CETL 8000/2000) to prepare TAs to teach students enrolled in laboratory and recitation sections. We piloted this course in the School of Biology in Fall 2012. Pending the success of this initiative, CETL may eventually extend this program Institute-wide. The purpose of this study is to evaluate whether CETL’s new Teaching Assistant (TA) development program for the lab sciences improves TAs teaching effectiveness in undergraduate labs. The research question we are exploring is: How effective is CETL 8000/2000 in preparing TAs to implement learner-centered approaches to teaching in the lab sciences? Given national trends, assessing the impact of our TA development program has broad applicability beyond Georgia Tech.

Methods and preliminary findings

We are triangulating several kinds of data to evaluate the program’s utility in improving TAs’ teaching effectiveness including a pre/post-knowledge survey which measures awareness about teaching concepts as well as confidence; the Approaches to Teaching Survey, a validated instrument which measures the continuum of instructor- to learner-centered approaches to teaching; pre/post microteaching; learning portfolios and blog posts to examine attitudes and beliefs about teaching; teaching evaluations; direct classroom observations across two semesters; and individual and focus group interviews. We will expect that most TAs will have a low level of knowledge and an instructor-centered approach to teaching at the beginning of the course. If the course is successful, by the end of the semester, we expect that TAs will become more knowledgeable about teaching and adopt a more learner-centered approach to teaching. We will present preliminary findings from this longitudinal study to evaluate the impact of the CETL program on TAs’ process of becoming learner-centered teachers.
BreakThru: Virtual Mentoring for STEM Education*

Robert L. Todd, College of Architecture/CATEA

The influence of digital media has changed the way students learn, play and socialize. As a result, researchers at Georgia Tech and the University of Georgia (UGA) have partnered to develop a virtual learning environment that combines creative avatars and social networking tools to help high school and college students with disabilities to succeed in science, technology, engineering, and math (STEM) programs. The universities work alongside Georgia Perimeter College and the school systems of Georgia’s Greene, Clarke and Gwinnett counties to serve targeted students.

Funded by a 5-year grant from the National Science Foundation’s Research in Disabilities Education program, the Georgia STEM Accessibility Alliance (GSAA)/BreakThru virtual world provides a Mentoring Island where students meet and interact with mentors to address their STEM education needs. Students have the option to create avatars that simulate their disability realities (e.g., wheelchairs for mobility, orientation tools for blindness, etc.) or create a personal avatar that is entirely different from their physical self. BreakThru has constructed a virtual environment in Second Life that exemplifies the best of accessible and universal design, with special care taken to accommodate assistive technologies and non-standard browsers. The Mentoring Island is the primary meeting space for mentoring and teaching, social networking, academic support, transition assistance, and research participation for the initiative, but the project makes extensive use of common social networking tools (SMS, Skype, Facebook, etc.) to supplement the virtual interaction. BreakThru teachers and faculty can also virtually access custom training modules on universal design and evidence-based teaching strategies for their classrooms and labs.

The project serves as a pipeline between secondary and postsecondary institutions to strengthen students with disabilities’ capacities to access and succeed in STEM programs across critical junctures: high school | two-year college | four-year college | graduate school. The overall project goal is to increase the number of students with disabilities enrolling in STEM classes and majors; increase retention and graduation rates; and increase successful entry rate into STEM graduate programs.

Potential Impact for Schools in Georgia and the Nation

Current efforts are focused on Georgia pipeline schools and students with disabilities, but outreach and dissemination efforts extend nationwide and assist all students who need assistance in STEM, with or without disabilities. BreakThru has been created to provide broad impact through its applicability to students and faculty who are separated geographically and through its potential to gather a national/international networking of STEM stakeholders. The digital media model is scalable to other secondary and postsecondary institutions throughout the nation. Its focus on universal design for learning and inclusion of accessible materials are aimed at assisting all students in need.

* This work supported by Award #1027655 from NSF-Research in Disabilities Education.
Science Learning Integrating Design, Engineering and Robotics (SLIDER): Balancing Inquiry, Design, Standards and Classroom Realities*

Marion Usselman, College of Science/CEISMC
Mike Ryan, College of Science/CEISMC
Sabrina Grossman, College of Science/CEISMC
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The new Framework for K-12 Science Education, developed by the National Academy of Sciences, proposes to markedly increase the profile of engineering practices and concepts within the domain of K-12 science education. There is a concurrent push to increase the level of experiential and constructivist learning. The challenge for developers of K-12 instructional materials for core science classes is to create educational experiences where students learn the disciplinary concepts and practices mandated by state and national standards, while concurrently exposing students to important concepts from other domains and maximizing the experiential nature of the student explorations. To be effective and sustainable, the curriculum also needs to be mindful of the realities and limitations inherent in our modern system of schools: accountability pressures, regular benchmark testing of students, large classes, ranges in teacher pedagogical content knowledge, and the pervasiveness of annual standardized testing.

Georgia Tech, through the Center for Education Integrating Science, Mathematics and Computing (CEISMC), currently has an NSF-funded Discovery Research K-12 (DRK-12) grant entitled Science Learning Integrating Design, Engineering and Robotics (SLIDER) that entails developing, implementing and evaluating an 8th grade physical science curriculum that uses LEGO Mindstorm robots as the manipulative within a project-based inquiry learning framework. The curriculum needs to align with the Next Generation Science Standards, meet state curriculum standards, and be implementable in regular public school classrooms. Our team, consisting of curriculum developers, educational researchers, and classroom teachers, is developing the curriculum through iterative design and implementation cycles, borrowing from design-based research. Successive redesigns are based on multiple sources of data and feedback: task analysis and research on science content learning, alpha-testing of the activities in the laboratory (without students), curriculum design with our teachers during professional development workshops, and pilot testing curriculum in authentic contexts (i.e., with our partner teachers implementing the curriculum in their classrooms). Instruments include design decision logs, classroom observation protocols, surveys, student artifacts, and concept inventories.

The level of experiential or constructivist learning in science classrooms is generally conceptualized by levels of inquiry. A common scale of inquiry encompasses Confirmation Inquiry, Structured Inquiry, Guided Inquiry, and Open Inquiry. Often there seems to be an implicit assumption among reform science educators and learning science researchers that the more “open” inquiry the better. The constraints of modern schools and the requirement that students master defined and assessable disciplinary content mandate a level of scaffolding that is seemingly inconsistent with Open Inquiry. Likewise, researchers studying the engineering design process have developed hierarchical categories of design, with Free Design being analogous to Open Inquiry. This poster will explore the design research methodology and the different curricular compromises that must be made when creating multi-week instructional units for science classes that encourage deep learning and increased student engagement, but that can also be realistically implemented in regular schools by regular teachers.

* This work is supported by an NSF Discovery Research K-12 (DRK-12) grant entitled “Science Learning Integrating Design, Engineering and Robotics (SLIDER).”
Students describe mathematics as boring, irrelevant to their lives, and useless. These perceptions are worrisome since studies indicate that success in mathematics influences students’ ability and interest in pursuing studies in science, technology, engineering and mathematics (STEM) disciplines. On the other hand, many researchers have shown that robotics motivate students to discover, learn, and explore. Consequently, it is imperative to ask: Can we take advantage of the purported motivation that robotics generate to promote mathematics learning?

Some obstacles for enriching mathematics instruction with robots are the lack of ready to use lesson plans and the lack economical robot sets. This work will showcase an easily built and economical educational manipulator arm designed for enhancing the learning and retention of high school mathematics. The manipulator, called PickTul, is a four degree-of-freedom SCARA type robot arm. Via this technology, students have the opportunity to use the mathematics they learn in class within the context of real world engineering problems. The work is documented in the form of detailed lesson plans for future use by teachers. To date, lesson plans for trigonometric functions (sine, cosine, and tangent), inverse trigonometric functions, and the law of cosines have been created. The lesson plans are designed to encourage students to explore mathematics in the physical world and to align with the recently adopted Common Core Georgia Performance State Standards. Longer term, this work seeks to motivate students to learn mathematics by providing a platform through which they can see the usefulness and relevance of mathematics in their lives.
Investigating How Students and Experts Use Diagrams to Solve Engineering Problems

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Introduction: Our goal is to improve student learning in entry-level engineering courses. About one in five students fail or withdraw from these courses. We believe students struggle, in part, because textbooks and classes misrepresent the problem-solving approach as one that is stepwise, linear, and non-iterative. Further contributing to the problem is that most novice engineering students have been trained in previous courses to employ formula-centered approaches to solve problems. We hypothesize that experts solve problems via a complex series of cognitive moves in a non-linear and iterative fashion, which is neither captured in the textbook description of the process, nor is modeled well for students in classrooms. We believe that experts, to solve problems, successfully negotiate two critical problem-solving steps: 1) the translation of a verbal account of the problem into a diagram that visually articulates the essential aspects of the problem, and 2) the transformation of the diagram to mathematical equations that are used to find a numerical solution. We contend that entry level courses fail to embrace the centrality of the diagramming step, which perpetuates shallow understanding and diminished problem solving capacity. As a first step towards addressing this problem, we are studying the cognitive strategies used by novices and experts to transform a textual account of a problem into a community-sanctioned diagram.

Approach: We conducted a qualitative study of the cognitive strategies problem-solvers use to transform textual accounts of problems into engineering diagrams. We collected data by videotaping experts and novices diagramming and solving engineering problems as they said out loud what they were thinking. Immediately afterwards, we interviewed the subjects to assess what they were thinking as they diagrammed and solved the problem. To aid their recall, we cued their memories by watching relevant portions of the video. To date, we’ve conducted think aloud and retrospective protocols with eight novices, each of whom participated in two problem-solving sessions, and two experts. The problems that were developed drew on topics they were learning in a mass and energy conservation course taught in the Department of Biomedical Engineering at Georgia Tech. To solve these problems, students needed to understand and be able to formulate and solve mass balance equations for a non-reacting system operating at steady-state, for total mass or for individual species. We found, in the course of carrying out our studies, that estimation played a central role in the problem solving process, and we found significant differences in the way experts and novices carried out estimations, and in the extent to which they valued estimation as an important skill. Currently, we are developing a coding system to analyze the data. We expect this structured analysis of the protocol data to provide us with significant insights into the differences between how experts and students make estimations, and how these skills influence or otherwise affect their ability to generate and interact with diagrams to solve engineering problems.