

Title: Empowering students through the use of iPad technology

Hypothesis: iPads can be meaningfully integrated into the K-20 physics classroom to produce increased scientific learning among students and decrease achievement gaps.

Research Proposal:

With the support of the proposed iSTEM grant, I will conduct intensive research on the effect of using the iPad to integrate digital education tools into diverse K-20 physics classes. The proposed project has the research goal of testing the effectiveness of a fully technologically integrated classroom on decreasing achievement gaps in the four strands of science student learning set out by the National Research Council of the National Academies (NRC): know, use, and interpret scientific explanations of the natural world; generate and evaluate scientific evidence and explanations; understand the nature and development of scientific knowledge; and participate productively in scientific practices and discourse (NRC, 2007b).

The NRC has identified our K-12 STEM education pipeline as the primary driver of 21st century job creation in the United States and warns that lack of investment in both the K-12 system and the supporting education research will have a long lasting negative impact on the world economy (NRC, 2007a). Having worked as a high school physics teacher, a physics researcher and an Albert Einstein Distinguished Educator Fellow, I have seen first hand the dearth of proper research-supported technology implementation in America's classrooms (Byrne, 2009). I have taught students who are traditionally underrepresented in physics yet they have the abilities to thrive in physical science given the appropriate educational environment. Students are already equipped with many 21st century skills and there are a variety of technological tools available, but our schools are failing to integrate them into the classroom.

In order to ensure America's leadership in the sciences, the Presidential Council of Advisors on Science and Technology has identified six fields for improvement: providing deeply digital course materials, open-source modular course materials, improved assessment systems, personalized online tutoring systems, automated systems and software to aid teachers, and improved exchange of digital educational materials (PCAST, 2010). The iPad can be a transformative tool that has the potential to integrate these resources and package them dynamically so the learning process can be completely reimaged. Many of these tools have been tried before on other devices, but the iPad represents a potential tipping point with its portability, price, power and novel intuitive user interface. There are also applications for the iPad that are not possible on laptops, such as the Star Chart application, which allows students to identify and study stars and constellations by pointing their iPad different directions. The proposed project will make the iPad accessible to all students, with the goals of personal relevance, ownership of ideas, and will hopefully to help them build identities as people who can do science. My goal is to create a technology-enhanced physical science curriculum (or modules) by building on students cultural, social, cognitive, and linguistic resources (Warshauer & Matuchniak, 2010).

I have received \$5,000 of initial funding for equipment from the Women Investing in the School of Education to purchase a small set of iPads and run a pilot study. This preliminary study will be used to assess student interactions with the iPad and incorporate several motivated students into the research team (Kirshner, 2007). The teachers and students will have the opportunity to utilize open-source digital textbooks (Salpeter, 2009), simulations, labs (Wieman & et al., 2010), interactive homework sets with real-time learning assessments (Trawick, 2010), open-source lesson plans, remote-response systems (Stav & et al., 2010), course designed wikis,

collaborative resources, educational games (Hong & et al, 2009), and online course materials (Zhang & Almeroth, 2010), tutors (Revenaugh, 2000), and notes (Horney, 2009).

The iPads will be deployed in classrooms for a minimum of one semester and then be rotated through different classes taught by the same teacher in order to compare student-learning outcomes. To assess the impact of the iPad on the teachers and students I will be utilizing a variety of methods to collect data including video taping classes, interviewing students and teachers, Likert scale surveys, as well as pre, formative, and summative testing (see attached assessment scheme).

The proposed project will capitalize on the expertise of CU Boulder's DBER research group as well as the rich multicultural faculty in CU Boulder's school of education. I will directly utilize the knowledge and experiences of professor Otero (CU Boulder School of Education), who is known for her work on inquiry-based physics and physical science curricula (Goldberg et al., 2010) and an innovator of the Colorado Learning Assistant program (Otero & et al., 2010). The project will also utilize the infrastructure and classroom connections that have already been established through our work on the Streamline to Mastery project, funded through an NSF NOYCE MF/TF grant (0934921). Four teachers who are currently engaged in professional development through the NOYCE grant will join my research team and be fully engaged in designing the research project and the iPad deployment (see diagram 1). As we prepare a teaching workforce to embrace multicultural classrooms of students, such teacher training is critical (Towndrow, 2008).

My project will be evaluated on three broad categories consistent with the research questions shown below.

1. Can inclusion of the iPad increase student's conceptual learning?
2. In what ways do students identify with technology and how does this change over time? Does this "technological identity" correlate with their conceptual learning?
3. How does participation in the design team influence the growth and development of STEM teachers and high school students?

The first question involves traditional measures of conceptual knowledge and will be investigated longitudinally by comparing pre, mid-term, and post conceptual assessments, clicker question responses, and virtual lab reports throughout the a semester or year. I anticipate finding gains in at least one of the NRC strands: scientific knowledge, skills in communicating scientific findings, skills in critically analyzing scientific models, or in conceptions of science. The second question, which looks at how K-12 students' identities with respect to technology changes as a result of access to the iPad (Dodge & et al., 2008), is more qualitative in nature and will rely on data sources such as interviews, video and Likert surveys (where appropriate). The videos, surveys, and interviews will be analyzed using an emergent coding scheme to identify salient aspects of student behavior. Examples of student behavior what would be of interest include how (or whether) a student takes the lead on a group technology task and how they talk about themselves when referencing digital homework or activities. I will also look at any differences in the frequency with which they turn in technology-based homework in comparison standard paper and pencil homework. The third question is mostly descriptive in nature. I will document how individuals participate and how their participatory rolls evolve over time when teachers, students, graduate students, and faculty members work cooperatively in a research design team. Data for this question will rely mostly on video data and interviews. Again, I will use an emergent coding

scheme to map out individuals' participation and changes in their participatory rolls. The findings will be used to inform the teacher preparation program at CU Boulder.

The teacher preparation associated with using iPads with diverse populations will be disseminated in three ways. The first and most direct method of dissemination will be through the four teachers who will be participating in the research design team. As part of the Streamline to Mastery program the teachers have already committed to providing professional development for six other teachers over the next five years. The second method of dissemination will be through the Colorado Learning Assistant Teacher preparation program, which is nationally emulated in at least 25 universities. I will develop a technology-based activity, which will be used in the LA course. The goals of this activity will be to demonstrate how technology can enhance the conceptual learning in and out of the classroom and to help LAs (future teacher and future grad students) learn to use technology to actively engage students. Based on the results of my initial findings, we anticipate expanding the study to a larger number of schools. I will present my results at a National Science Teachers Association's convention, an American Association of Physics Teachers' convention, the MJ Murdock Foundation's Partners in Science meeting, as well as at CU's DBER and PER meetings. My research will hopefully result in articles for both research journals and educational trade publications.

This proposal bridges science education, technology, and culturally relevant instruction. As a teacher, researcher, and technology expert situated in the midst of these resources, I am particularly suited to investigate the use of technological tools and create bridges from the classroom to the academy.

Outcomes of the Proposed Project

This project will greatly benefit me as a future STEM educator. I have been a high school physics teacher, a physics researcher in the fields of experimental condensed matter and optical physics, and I have worked at the National Science Foundation. My experiences have made me uniquely suited for bridging communities of STEM educators in disciplinary departments with the STEM educators in the Schools of Education. The opportunity to work under an iSTEM grant in the DBER community will allow me to further develop my ability to work with interdisciplinary groups. The skill of creating both vertical and horizontal integration between K-12 schools and all members of the STEM community within the academy is something I hope to capitalize on during my future professorship.

This project will have an immediate impact on the School of Education through one of its research projects. The Streamline to Mastery project, which is working with teachers in Denver, will be provided with expertise and resources that will allow it to branch into several new areas of research. These new research emphases would also represent novel avenues of research for CU's School of Education. Based on the success of the initial study the project has the potential to be extended and scaled up to be a significantly larger research project.

This project will benefit the CU community as a whole in several ways. By using the findings of my research to create a LA learning unit focused on using data-supported technological teaching techniques I will contribute to the growth of these future educators. The LA students will be able to use the skills from this lesson in classes that they help instruct, which reach into each of the STEM disciplines at CU Boulder. This partnership between the School of Education and the DBER community will also help expose members of the School of Education to the methods and

techniques of classically trained scientists. The firewall that often exists between schools of education and the sciences only acts to exacerbate the divide between how social science and classical science research is practiced. It is imperative that such positive interdisciplinary relationships are forged for STEM education to make the gains needed to engage our continually diversifying student populations.

This project will benefit the broader community by working directly in our local schools to provide opportunities and resources. The teachers involved in the proposed project work in Title I schools that work with primarily minority populations. Students in these schools are being left behind their peers in staggering numbers, particularly with respect to access to technology. By bringing the technological tools directly to the school we can ensure that students are getting the exposure and skills that are increasingly important in the 21st century. With this project I'm looking to create the classroom of the future that, from its inception and throughout its development, capitalizes on the social, cultural, cognitive and linguistic resources of students. Instead of creating something for privileged students and then trying to fix it for the rest of society, I will work to create a program that is designed with the experiences and knowledge from the broader community indelibly engrained in its foundation.

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