

Design-based Information Technologies Learning Experience Project for K-12 STEM Outreach

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ABSTRACT

This paper presents the design of a large K-12 STEM outreach project supported by the National Science Foundation (NSF). It impacts IT education among six public high schools in a metropolitan area. The designed activities of the project are presented and shared with the education research community to invoke discussion. The project is currently in its first year of a three-year grant period. The lessons and experiences learned so far are also summarized for discussion.

BACKGROUND

Information Technology (IT) is an applied computing discipline in response to the practical, everyday needs of businesses and other organizations. It contributes to the “T” for technology in the STEM (Science, Technology, Engineering, and Mathematics) disciplines that are in high demand for skilled workers in the US. A January-2014 report from U.S Bureau of Labor Statistics projects IT (Information and Communication Technologies) jobs are among the jobs with highest growth rate from 2012 to 2022 (Occupational Outlook Handbook, 2014). Information Security Analysts tops the IT job growth list with a job increase rate of 37%, clearly higher than the national average. Today's business managers realize that the best weapon to battle the ever-growing cyber threats and attacks and protect business continuity is reinforcing network and system security. Companies are investing in newer, faster technologies supported by mobile and cloud computing approaches. A survey to 500 enterprises worldwide for the measure of cloud computing adoption rate reports the penetration rate of virtualization increased to 38.9 percent. 86.5 percent of these companies were reported as virtualized to some degree (Marshall, 2011). System administrators with proper training in security and virtualization technologies will be in greater demand.

Despite of the increasing job demand, the K-12 education in the US is not preparing enough students to pursue a major in IT related field. The country has to rely on hiring foreign workers or outsourcing many IT jobs to the developing countries such as China and India. 77 percent of 2013's H1B Visas, the special occupation labor visas that allow the foreigners to work in the United States, were granted to technology occupations. Four in five of these jobs are in Computer System Design and related services. And almost half of these jobs are Computer System Analyst (U.S. Department of Homeland Security, 2013). Many US high schools offer

computer science (CS) as the only advanced placement (AP) technology course, created by College Board. Tens of thousands of students take AP CS exam every year. The 2013 statistics show that there were no girls taking AP CS exam in three states, no black students taking it in 11 states, no Hispanic students taking it in 8 states. The number of female students in IT was dropped by more than 50 percent in the past 20 years (The Leadership Conference, 2015).

Regionally, there is a significant shortage of IT workers. Three of the top five Ohio occupations above 75th percentile for average earning, growth, and job openings are Network and Computer Systems Administrators, Application Developers, and Computer System Analysts, as reported by Ohio Department of Job and Family Services (Occupational Trends, 2010). Future STEM jobs will cut across educational levels, although the great majority require some form of post-secondary education including industry certifications, good and high paying jobs in information technology do exist for high school graduates who are not in a position to immediately move on to college (Carnevale, Smith & Melton, 2012). Preparation in IT provides an entry point into the workforce and future college degrees for high school graduates from traditionally under-represented groups in the STEM fields such as urban youth. If we are going to prepare students for careers in IT, in addition to student experiences in the field we need high school teachers with a basic understanding of IT and career pathways appropriate for students from a wide variety of schools.

In 2014, University of Cincinnati received a 3-year grant from the NSF to promote IT education to six urban high schools through multifaceted approach that affects and benefits the IT educational stakeholders in the region including the students, parents, and in-service teachers from six public high schools, 30 pre-service science teachers, university faculty and community partners, and IT industry leaders.

The project is designed to stimulate student interests in IT in a highly hands-on, project based learning environment through a series of in-class and extracurricular activities. It also emphasizes on attracting female and minority students to apply for a college degree in IT. As the project is still in its initial stage, there are insufficient data collected to answer a set of research questions we proposed to the NSF. The rest of the paper will concentrate on the unique design aspects of such a large K12 outreach effort, in hopes that the proposed outreach model can be disseminated and replicated in other regions to create a greater impact on the nation's IT education.

PROJECT DESIGN

Participants

The project has the capacity of directly serving 180 students in grades 9-12 with the summer program serving for some as an exposure to IT experiences and for others, who successfully complete graded assignments during the summer, a credit bearing college course. We have intentionally selected schools with varied student demographics, five are Cincinnati Public Schools and one is suburban high school. Four of these schools have high poverty and minority populations-- students typically under-represented in IT and STEM-- and one urban pre-college magnet school and one suburban school. In addition to the IT fundamentals exposure opportunity, approximately 30 students will complete an advanced IT course receiving additional University credit for the course. Finally, 15 highly skilled and interested students from the summer program will work in a grant funded internship. The project will also impact students at the school sites through the IT clubs and afterschool IT activities. Over the three years of project period, more than 30 new teachers would gain direct knowledge and experience in IT. The

impact of these teachers would be close to 6000 additional high school students, most in high needs schools.

Activities

The designed activities are illustrated in Figure 1 and explained below.

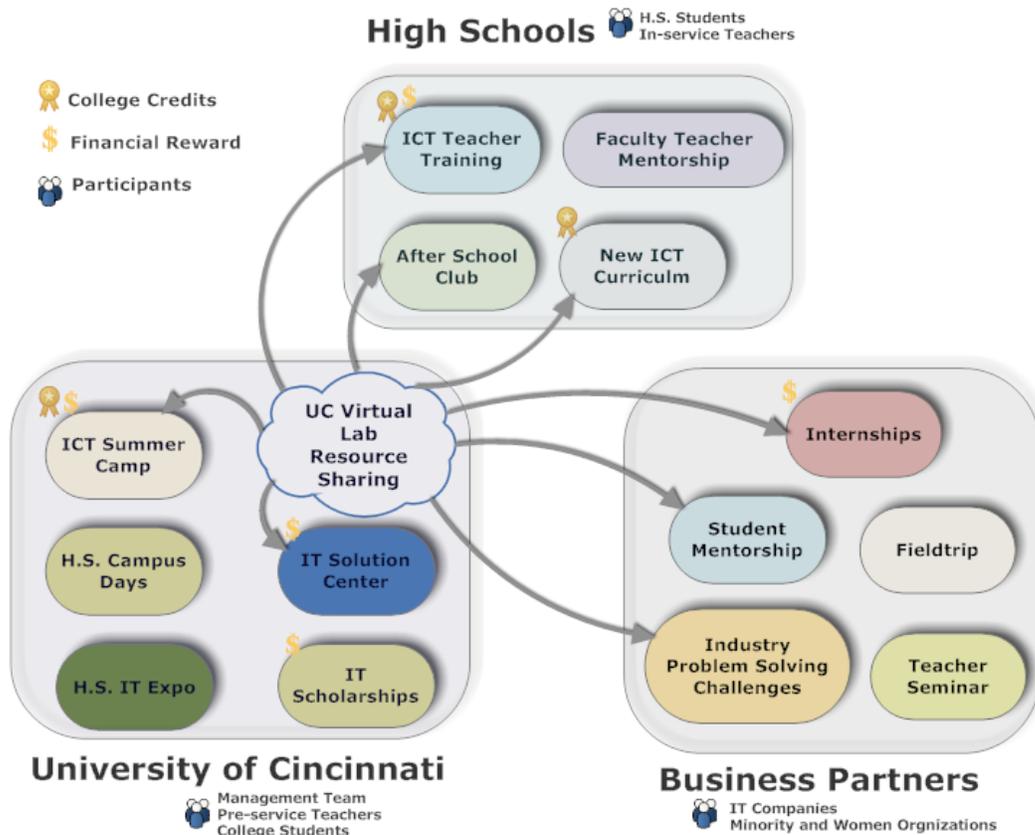


Figure 1. Proposed Activities

1. **Summer Intensive Program in IT:** The Information Technology program at the University of Cincinnati focuses on Problem Solving, Communication and Hands-on technical skills. These are essential skills for successful IT professionals. The summer program is designed to incorporate these three core skills in a project-based active learning environment. Over the three week summer program, students will participate in four learning modules with successful completion will allow the students to receive course credits for UC's IT1050 - Fundamentals of Information Technology. The units included in this course include: 1) a basic computer literacy including technology concepts, terminology hardware components and software applications; 2) computer networking, database management and systems design challenges; 3) web development; and 4) basic IT research, problem-solving and management skills.
2. **Advanced IT Course:** A second IT course will be developed to be taken by students during the academic year at their high schools. Information Security and Assurance will be delivered in a co-teaching fashion with university faculty providing the specific IT

content delivered in a web-format and a high school IT instructor leading design and project activities. Resources for the course will be housed in a shared cloud-computing environment and materials will be provided to the schools, students and teachers to insure they have sufficient resources to implement the course.

3. **Student and Educator IT Clubs:** The students will work with the pre-service teachers at the partner schools and an assigned teacher from the school to form a school-based IT club. The clubs will provide on-going activities in IT for summer camp participants to build on the experiences gained in the summer program.
4. **Internship Opportunities:** Paid internship opportunities for a small number of advanced or highly motivated high school students will be offered through the IT Solution Center. In order to receive a paid internship students must have attended the summer intensive and be taking or have completed the advanced IT course during the academic year. The internship experience will provide extended opportunities for high school students and introduce them to the business aspects of IT careers.
5. **In-service Teacher Development:** Partner schools will identify a licensed teacher interested in implementing IT courses at the school site. The teachers will be provided with a graduate level special topic IT course to prepare them to implement the design challenges involved in a university course, IT2030 Information Security and Assurance. The high school teachers will learn the background content needed to respond to the implementation demands of the design challenges. The special topics class will also develop a deeper knowledge base of IT careers and skills. High school teachers will be mentored by UC IT faculty to develop their own learning plans and goals. In addition, these teachers or a different teacher will serve as IT club facilitators and work directly with the pre-service educators and students.
6. **Mentoring and Field Trips:** Mentoring activities take place at two levels – student and teacher. Students in the advanced IT course and serving in internship will be assigned a mentor from industry or the UC IT department to guide them with academic preparation and career readiness. The mentoring will take place at program sites and online media, especially through a virtual computing lab as the primary platform. Industry partners will invite secondary students participating in the IT clubs to visit their work-sites through field trips or job-shadowing experiences. Minority and women IT organizations collaborated in this project will teach seminars during HS Days, lead online forum discussions, advise student team projects to compete in the annual IT High School Expo, and mentor targeted minority and female students during their internship.

LESSONS LEARNED

Hiring dedicated project personnel: the project directly impacts a large number of students and teachers, seven educational institutions, three IT nonprofit organizations, and the major industry leaders in the region. Building project support to articulate communication among the stakeholders, creating coherent visions on the achievable goals, and keeping track of and appropriately reporting the project progress are the keys to success. A project director was hired as the dedicated personnel, who coordinates all the designed activities and facilitates

communications and logistical aspects of the project. One school liaison per school was identified to recruit students and make sure the project activities align with school regulations and education needs.

Close collaboration with industry: the industry partners were reached through the advisory board of the School of IT that represents 35 companies in the region. Their supports, including providing industry shadowing and internship, are critical for students to gain hands-on experience to solve the real-world problem. We are surprised to see that many companies and nonprofit organizations already started their K-12 outreach programs. Reaching out and collaborating with them early creates mutual benefits that help them grow and invest on their future employees and release our burden of creating all the training material on our own. For example, the project facilitates the minority students to obtain the membership to the Black Data Processing Association (BPDA) to expand this 25-year old local minority organization. In return, BPDA provides IT experts to give keynote speaks and provide one-on-one mentorship to our summer camp participants.

Document and collect data early: to answer the proposed research questions, the research instruments have to be carefully designed and adjusted based on the individual school situations. Meetings were arranged with the school liaisons to design the student application forms and needs assessments before the summer camp. These forms will be collected to create the baseline data for the subsequent research.

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