University of Cincinnati UC Scholars Academy: Preparing Students for STEM Undergraduate Careers

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Abstract

The University of Cincinnati along with Hughes STEM High School, an urban public STEM high school has developed the UC Scholars Academy to 1) Increase the number of students who graduate college and are career ready; 2) Increase the number of students entering the University of Cincinnati and other local colleges; 3) Increase the number of students enrolling and completing STEAM degrees; and, 4) Develop an effective, sustainable and replicable college and career readiness program model. The UC Scholars Academy is a best-practice model for facilitating college and career readiness for greater Cincinnati students, with a special focus on supporting the tri-state's most underserved students to bring to reality a more diverse local student body and workforce that increases the vitality of the region. The Academy is a deep and systemic partnership among UC, Hughes STEM High School, and other community partners, which was created to demonstrate the validity of our college and career readiness approaches. There are two key initiatives of UC Scholars Academy: The UC Scholars Academy Summer Bridge and UC Scholars Academy 21st Century School-Year Program.

In the inaugural year of this program, students participated in Information Technology, Leadership, Art, Mathematics, Nursing, Allied Health and Engineering Modules during a three-week bridge program. The students in the program were rising Juniors and Seniors. Students in the program took pre- and post-Math assessments along with a STEM attitudes survey. Additionally, at the conclusion of the program, the students participated in semi-structured interviews and a focus group.

From the pre-assessment, the students tested at an Algebra I level although they had passed Algebra II at Hughes. The post-test showed a slight improvement in their conceptual understanding. More importantly, the focus groups revealed that the students now understood the rigors of successfully completing Mathematics courses. The students requested extra-curricular activities focused on increasing their Mathematics competency.

Introduction

STEM (Science, Technology, Engineering, and Mathematics) literacy is viewed as critical for global competitiveness, as well as for individual success in a highly technological world.[8]Despite this growing need, there is a persistent shortage of students interested in STEM careers or with the academic preparation necessary to pursue these careers after high school. This career pipeline problem is further complicated by the fact that fewer individuals from disadvantaged backgrounds are entering STEM fields.[6] Underrepresented and struggling learners consistently

underperform in STEM subjects and careers[2,9,10,12,14,23]. In addition, these learners have less opportunity and access for participation in STEM learning experiences.[11]This indicates that there is a need for a concerted effort to engage these students in STEM learning that is meaningfully engaging and authentic.

Literature Review

Students are not perceived as having the requisite training to compete in college or industry. Young people's efficiency in grasping math concepts hinders their ability to fully participate in the mainstream economy. Employers have increasingly made note of student mathematics deficiencies. They argue that many students enter the workforces lacking the mathematical skills to compete at the requisite levels to move our society forward.

The National Research Council (NRC) has defined Next Generation Science Standards (NGSS). The NGSS includes the critical thinking and communication skills that students need to be successful in their poet-secondary STEM careers. Ohio's New Learning Standards for Science lists the highest cognitive domain as "designing technological/engineering solutions using science concepts"[19]. This "requires students to solve science-based engineering or technological problems through application of scientific inquiry. Within given scientific constraints, propose or critique solutions, analyze and interpret technological and engineering problems, use science principles to anticipate effects of technological or engineering design, find solutions using science and engineering or technology, consider consequences and alternatives, and/or integrate and synthesize scientific information"[20,21,22]. The report: Engineering in K-12 Education: Understanding the Status and Improving the Prospects advocates for a more systematic linkage between engineering design and science inquiry to improve learning[16].

The idea of "scientific literacy" for all students was previously proposed by Science for all Americans[24]. The belief is that scientific literacy, synonymous with "public understanding of science," will enable individuals to participate more intelligently in the productive sector of the economy[26]. Higher levels of scientific literacy among the populace translate into greater support for science itself[25].

In order to achieve the goal of increased literacy, students should be given access to increased learning opportunities. The National Science Education Standards[17] in the work of the American Association for the Advancement of Science (AAAS)[1] and the National Science Teachers Association (NSTA)[18] have called for an increase in the amount of authentic learning. Inquiry design is also being viewed as a pathway to authentic learning that can support increased student learning of scientific concepts.

Benenson[4] argues that system-wide reforms in science event caused by technological demands of society, and he demonstrates how "everyday technology" could be used as the context for promoting scientific literacy. A Learning By Design (LBD) approach has been adopted by Kolodner[13]. The LBD approach is utilized as the vehicle for teaching science concepts. The students engaged in this approach generally outperform their peers in various areas including the ability to design experiments, plan for data gathering and collaborate[13]. Similarly, Mehalik, et al.[15] suggests that a systems design approach for teaching science concepts is superior in terms of

knowledge gain achievements in science concepts, engagement, and retention when compared to a scripted inquiry approach. This was especially helpful for underachieving African-American students.

Why Hughes?

Hughes STEM High School, located in Cincinnati, Ohio and part of Cincinnati Public Schools, is a public high school serving grades 7-12. The school offers a creative focus in the areas of Science, Technology, Engineering, and Mathematics (STEM). Hughes is a career technical high school with four identified career pathways: Engineering, health, plant and animal sciences, and information technology. The instruction at Hughes STEM embeds project-based learning and supports social-emotional development. The high school works to integrate community partners into the school day to assist with college and career exploration. Currently 995 students attend Hughes; 95.6% of the students come from minority backgrounds with 84.8% being classified as economically disadvantaged. The Hughes High School 2012-2013 School Year Report Card indicated that students in tenth grade routinely underperformed on reading and mathematics sections of the OGT (Ohio Graduation Test). Only 65.6 % of students passed the reading section and only 63.9% passed the math section. These numbers indicate that students at Hughes High School will be unprepared for STEM college programs. The UC-Hughes STEM Partnership programming, including a Summer Bridge Program and an academic-year Career and College Immersion and Leadership Development Program, will prepare students to enroll in STEM college programs and to eventually succeed in STEM careers.

The Program

The first cohort of students served by the UC-Hughes STEM Partnership was a cohort of 11 rising juniors and seniors who attended the Summer Bridge Program.

The Summer Bridge Scholars Program is a 3–week residential summer program. The summer program is extremely intensive. The objective of the program is to create a "learning community" of students and to help them develop the academic and social skills necessary for achieving academic excellence, while at the same time building their self-confidence, strengthening their academic skills, and acclimatizing them to the campus environment.

The Summer Bridge program was designed to incorporate core academic reinforcement, critical thinking, and social-emotional skills training in a project- and field-based active learning environment. Over the three-week, residential summer program, students participated in five learning experiences:

1) Math learning and problem solving: Students were be immersed in deep mathematical learning and exploration. Students participated in collaborative problem solving with complex, real-world math facilitated by academic coaches from UC.

2) STEM college and career immersion led by the Colleges of Engineering and Applied Science (CEAS); Nursing, Allied Health Sciences; Arts and Sciences, and the School of Information Technology (IT): Students engaged in a variety of experiential learning

opportunities with UC STEM colleges and STEM industry partners. The experiences were hands-on and make connections to college and career pathway choices.

3) Interdisciplinary STEM project led by the College of Design, Art, Architecture, and Planning (DAAP): Led by DAAP faculty, students completed an investigative research project that studies the environmental issue of "Bees and Colony Collapse Disorder." The project had an ecological focus and the subject was explored through web-based, arts-based and experiential modes of research.

4) Information Technology course and embedded technology integration: Students participated in a Speaker Series featuring IT professionals and UC students majoring in IT at The College of Education, Criminal Justice and Human Services. Students also took a college-level course, "the Fundamentals of IT."

5) Critical Skills workshops and team building/Collaboration opportunities: Students participated in a variety of workshops that explicitly build critical thinking skills and aspirational/goal setting abilities that will enable students to become more college ready. Additionally, students engaged in interactive team building exercises

A **sample** daily schedule with these five components is illustrated in the table below.

Time	**Activity**	**Lead**
8-9	Breakfast	Resident Assistants
9-10	IT Speaker Series	School of IT
10-11:20	Fundamentals of IT course	School of IT
11:20-12	Lunch	University Student coaches
12-1:15	Math Learning and Problem Solving	Math teacher/educator/student teacher team
1:15-3	Interdisciplinary STEM Project-based Learning	DAAP
3-5	STEM College and Career Immersion	CEAS and reps from the Colleges of Nursing, Allied Health Sciences and Arts and Sciences
5-6	Break	--
6-7	Dinner	Resident Assistants
7-8:00	Critical Skill Workshops	Leadership Scholars (community partner)
8:00-9:00	Team building/Collaboration	Recreation Center
9-10:30	Organized Fun	Resident manager and RAs

During the academic year, following the Summer Bridge experience, the Summer Bridge cohort and all 11th grade Hughes students began participating in an in-school College and Career Immersion and Leadership Development program that will support and sustain deeper learning by helping students envision their academic pathways and careers after high school graduation. Faculty from Hughes and UC lead this program, with Hughes teachers focusing on instruction

and UC faculty focusing on programs that engage external partners. Academic year programming directly emphasizes program objectives of engaging students in mathematical programming; connecting students with STEM professionals; immersing students in STEM industries; and involving students in academically challenging coursework and critical skills/teambuilding workshops. This program will use a three prong approach to encourage deep learning about college and careers in STEM fields. The three components and their related activities include:

1) **"Engage"-** This component focuses on interactive job shadowing career planning. The project leader is the UC Center for Community Engagement.
    a. Resident Scholars Program (RSP), designed by Procter & Gamble (P&G), is a one week job shadowing experience for high school minority students interested in pursuing STEM careers. Current RSP partners include P&G, GE, Duke and Toyota. RSP has consistently received high ratings from its participants and has been successful in inspiring students to pursue STEM careers for the past 10 years. Approximately, 80% of RSP alumni have chosen to pursue a career in STEM, and 70% of those students credit RSP for enabling that decision.

2) **"Prepare"-** This component focuses on college readiness and awareness of STEM careers. Project leaders are UC's College of Education, Hughes faculty, and Leadership Scholars.
    a. Power Lunches are networking events held between a group of students and area career professionals designed to increase student awareness around a selected topic, such as STEM careers.
    b. Parents Academy, a research-based parent education program that has monthly sessions at Hughes dedicated to teaching parents how to work with their children to successfully navigate the college application and enrollment process.
    c. Field Experiences & Workshops: Nine colleges from the University of Cincinnati will partner to provide monthly workshops and/or field experiences that expand Hughes students' understanding of STEM careers and to prepare students for post-secondary education. Students will meet with a team of advisors from Hughes and UC to develop a personalized college readiness plan.

3) "**Develop"-** This component focuses on career readiness and academic support. Project leads are the UC-Hughes Resource Coordinator and Hughes faculty.
    a. Advisory sessions are highly interactive sessions that will occur weekly, focusing on leadership development, self-confidence, time management, problem-solving, decision making, goal setting, communication/presentation skills, and collaborative teamwork. Students will also receive support to improve their skills in math and literacy and assistance with ACT preparation.
    b. The Speed Mentoring event, piloted in spring 2015, is an intensive networking event that involves Hughes 11th graders interacting with 45-50 African American business mentors about the topics of STEM college degree programs and career readiness.

Expected Outcomes

The projected outcomes include both learner outcomes as well as overall program outcomes. The learner outcomes are: 1) Improved math content knowledge; 2) Improved interest and attitude in STEM education and careers; 3) Improved STEM-enabled identity; and 4) Increased student social-emotional competence and persistence/grit. The program outcome is an aligned and articulated college and career readiness programs that can be offered to more students at Hughes STEM High School and eventually to other schools in the region. These outcomes are based on program objectives surrounding academic support and STEM engagement programming and will be measured during the Summer Bridge Program and throughout the academic year. For the purposes of this paper, we are focusing on STEM attitudes and how the program impacted their perceptions of STEM careers.

Measuring Expected Outcomes

Students from cohort #1 took a variety of pre/post assessments and participated in structured interviews at the conclusion of the summer program. To measure improved interest in STEM education and careers UC developed a STEM Interest Survey: This survey has been tested and refined to measure student interest and attitude toward STEM education and careers. This project will continue to validate this pre-existing instrument. In this paper we will present the results from the STEM attitude survey as well as the semi-structured interviews.

In the future, the results from other expected outcomes will be presented. To measure improved STEM-enabled identity, the New General Self-Efficacy Scale[7] for students will be modified and used to measure students' self-efficacy in their STEM skills. This is an important measure as student self-efficacy has been found to be a strong predictor of academic achievement, course selection, and career decisions across disciplines. Students' belief in their ability to succeed in STEM education influences their choices of STEM-related activities, the effort they expend on those activities, the perseverance they show when encountering difficulties, and the ultimate success they experience in STEM [3, 5].

Student Impacts

Results from the Student Attitude Towards STEM survey shown in **figure 1** indicate that four students had an increase in STEM attitude, four students had a decrease in STEM attitude and three students' STEM attitude remained the same.

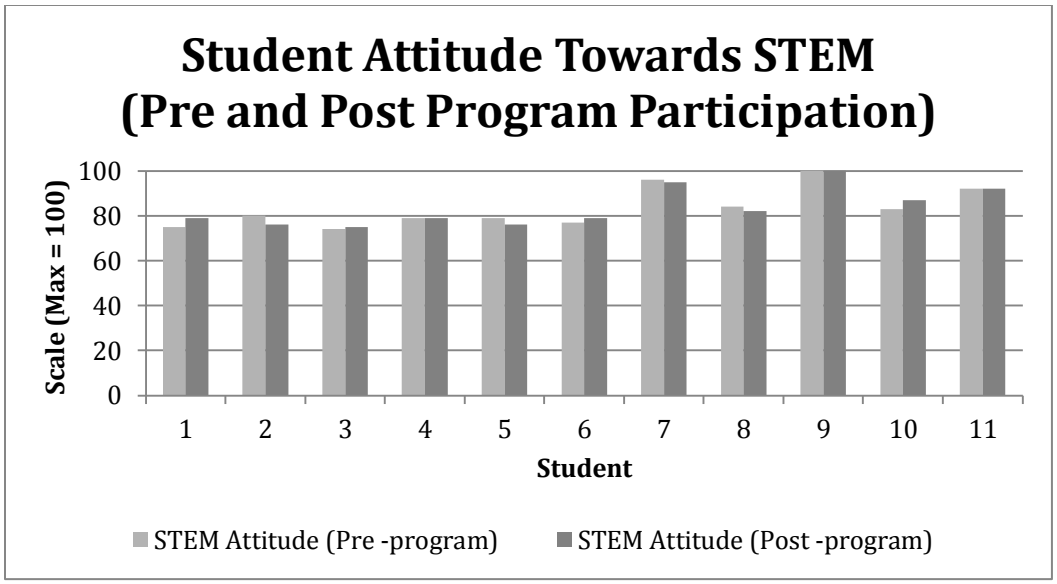

Figure 1: Pre and Post Program STEM Attitude Scores

Reviewing the students that had an increase in STEM attitude, students showed an increase in "Science is useful for solving everyday problems", "It is important for me to learn science", "I am interested in a career in science", "I am confident in my ability to write about my ideas" and "I prefer working on team projects rather than individual projects."

When analyzing the constructs of the students who had a STEM attitude decrease, students decreased in "I am interested in a career in science", "I am interested in a career in technology and "Math is applied in our everyday lives". All of the students with an overall STEM attitude decrease showed did however present an increase on the question "Science is useful for solving everyday problems".

The semi - structured interview questions provided further insight to the summer bridge experience and how students viewed careers in STEM. Students were asked the7 questions. Select responses are listed below.

Question 1: Was UC Scholars Academy what you thought it would be?

"Not at all, I thought it would be like college life. I liked the hands on experiences. It got interesting because I got to see the things I could do in college"

"Not at all! It was better. I got to do more than I thought we could do. Learned things I could do in college."

"It was. Discipline was taught well. I like the hands on experience"

Question 2 : Have your career goals changed or remained the same?

"Goals stayed the same. I am more confident. I learned about many majors. The program better defined what I can do with a degree"

"My pathway is engineering. I want to stay in mechanical engineering but I like I can work in fields with art or health"

"Stayed the same, but I'm confident in my choice. I can do a variety of STEM things with fashion including designing outfits…"

Question 3: Do you feel better equipped or more comfortable with your career pathway?

"Yes, more comfortable. Learned you can do it too!"

"I have narrowed it down. I still have time to research programs"

"Yes. I feel better. A main concern was tuition but I learned about the Cincinnati Pride program."

Question 4: What would you add to the program, delete and or change?

"Hours of classes need to change, math and engineering need to should definitely stay"

"Keep DAAP, nursing, engineering and math. Change the food, we need more carryout"

"Nothing. It's a life changing experience. Takes you to a whole new level"

Question 5: What programs should be implemented for Hughes students during the academic year?

"Math classes or tutoring at UC"

"Provide motivation with mentors so I know someone cares and that I will make it"

"Classes or tutoring here, especially in math. Maybe a college mentor."

Question 6: What programs should be developed for students who did not participate this summer?

"Workshops, tutoring. Like we got! Focus on recruitment"

"People aren't getting into STEM because they don't know. We need to tell them"

Question 7: Do you feel you had all the resources and support needed this summer to do your best?

"Yes. Most definitely. Better insight on STEM."

"Yes, great push that I needed."

"A great experience. Helped a lot of people grow, mentally. Gave everyone a head start of what college is really about"

Conclusions and Recommendations for Future Study

Students reported that they learned about STEM from their participation in the summer bridge program. The results from the STEM Attitudes survey show that students gained a better understanding of STEM careers. Although scores may have decreased in STEM attitude the majority of the decrease can be attributed to the "I am interested in a career in science" and "I am interested in a career in technology" questions. Decreases on the aforementioned questions indicate that students have had a chance to explore those areas and found they do not match their interests. The same students that had an overall decrease in STEM attitude all reported an increase on "science is important to everyday life", which indicates they have an appreciation for the field but they may not want to work in a STEM career. Students also reported that the program helped them understand the rigors of college and indicated more math courses would be beneficial to them during the academic year.

More studies are needed to compare student performance in the UC Hughes Scholars Academy. As the state of Ohio moves to more performance- based assessment starting the 2014-2015 school year, this comparison will become even more relevant. In order to sustain the program, the project team will need to pinpoint exact factors and degree of treatment needed to implement a successful program to 1) Increase the number of students who graduate college and are career ready; 2) Increase the number of students entering the University of Cincinnati and other local colleges; 3) Increase the number of students enrolling and completing STEAM degrees.

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