

# **Integrating a Faculty Directed Research Experiences into a High School Bridge Program**

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**Abstract**— With the echoes of the CAWMSET report still ringing in our ears, Standing Our Ground, October 2004, confirmed what we in the field knew to be true. The reality and challenge of increasing the number of historically underrepresented people in the STEM disciplines had increased at a time with the toolkit and pocketbooks were coming up empty. The new set of boundaries in this post-Michigan era had made a set of complex problems even more complex. The price the United States is paying economically, politically and socially at home and abroad for not utilizing the talents, skills and abilities of all of its citizens is too high. Research continues to demonstrate that we are not producing the next generation of scientists, engineers and technologists that we need for a stable future. Nationally, only 2 out of 5 African-American and/or Hispanic American students who begin in a STEM discipline will graduate with a Bachelor of Science degree in a STEM discipline. There are a number of rationales answering the question why, but leading causes are lack of K-12 preparation in math and science and lack of the financial resources necessary to achieve an increasingly expensive higher education. The disciplines housed in the College of Earth and Mineral Sciences at The Pennsylvania State University continue nationally to struggle to bring historically under-represented populations into our disciplines and into the related career paths. Answering this challenge is not easy and there is not just one solution. The College of Earth and Mineral Sciences has developed a unique partnership with a successful pipeline program by adding a twist, in creating a pathway.

Working with the UPWARD BOUND MATH AND SCIENCE, we have created a hands-on 30 hour research experience directed by faculty concluding with a formal judged research presentation. After 2 summers, we have directly impacted not only the learning of the participants, but our faculty and recruitment of incoming students.

## **Workshop Description**

The first section will focus on describing the use of best practices, student assessment, and methods of implementation of a student research experience as utilized in the Penn State Upward Bound Math and Science Center's Summer Experience in Earth and Mineral Sciences (SEEMS). This model of research integration into the curriculum can be used as an ongoing method to strengthen students' problem-solving ability and develop critical thinking, observational, and communication skills. Specific focus will be placed on implementing research curricula that follow best practices for equipping students to transition to postsecondary

education, as well as the use of relevant research topics and innovative resources and technology to “level the playing field” for students coming from resource-poor schools. Additionally, methods for ongoing assessment of students’ research performance will be illustrated.

The second section of the session will focus on practical suggestions for implementing a research component into already existing Upward Bound curricula or similar bridge programs. The ideas, resources and methods will be broad enough for various programs to incorporate student research into their programs as suits the particular program needs—some may wish to add research as a supplemental activity to the current curriculum or some may wish to rewrite part or the entire curriculum to integrate research into the entire summer instructional component. Information regarding further resources on math and science curriculum integration will also be presented.

Pre and post experience questionnaire, Pre and post mathematics readiness survey, 2 year record of application and acceptance into EMS programs and longitudinal data on Upward Bound Math and Science participants.

Establishing a partnership with the Upward Bound Math and Science Center at Penn State, one of the federally funded Trio programs, has forged this pathway, extending from a traditional pipeline program. The College of Earth and Mineral Sciences was provided with a rare opportunity to be part of an effective bridge program with a history of success and academic excellence. Since 1990, The Penn State Upward Bound Math and Science Center has addressed the needs of their targeted students, and are ambitious, attainable, and measurable. The stated purpose of the Upward Bound Math and Science Center--to generate in program participants the skills and motivation necessary to complete a program of secondary education and to enter and succeed in a program of postsecondary education; more specifically, postsecondary education programs that lead to careers related to the fields of math and science. While the purpose is clearly stated, it is not simple to accomplish.

Historically, summer and/or bridge programs are expensive to run and consume a great time of time, effort, and energy usually for an already over-extended staff. Working with Project Upward Bound offers a strategy to tap a pipeline that is already built, while sharing cost, expertise and reward. And the gain is more than simply the summer enrichment program; The College of Earth and Mineral Sciences is part of a 12 month, multi-year program, with multiple in-depth interactions with talented, hard working, motivated students. **Summer Experience in Earth and Mineral Sciences: SEEMS**, is truly a win-win-win.

SEEMS (Summer Experience in Earth and Mineral Sciences), our curricular innovation involves adding 30 hours of directed research to the existing Upward Bound Math and Science summer academic enrichment program. Students spend 6 weeks at Penn State, where they receive classroom instruction in core academic areas and participate in a collaborative team research project led by faculty and graduate students. SEEMS research projects emphasize creativity and critical thinking, and stress the teamwork, research and communication skills that are crucial to the future success of the students.

As a partner in the Upward Bound Math and Science program, EMS becomes the host providing access to labs and classrooms. As a collaborator, the College brings faculty, staff and graduate students together with engaged high school students infusing new talent, with teaching and learning opportunities for all involved. EMS is a teacher providing information on laboratory safety and courtesy, offering orientation to the college community and demystifying the disciplines housed in the college. EMS is also a bridge providing the SEEMS students with working professionals in fields and disciplines awaiting discovery. We partner in their success in the Upward Bound Math and Science program and in their undergraduate experience.

This model of research integration into the curriculum can be used as an ongoing method to strengthen students' problem-solving ability and develop critical thinking, observational, and communication skills. Specific focus has been placed on implementing research curricula that follow best practices for equipping students to transition to post secondary education, as well as the use of relevant research topics and innovative resources and technology to level the playing field for students coming from resource-poor schools. Additionally, a variety of methods for ongoing assessment of students' research performance are illustrated. The model offers practical suggestions for implementing a research component into already existing Upward Bound curricula or similar bridge programs. The ideas, resources and methods will be broad enough for various programs to incorporate student research into their programs as suits the particular program needs some may wish to add research as a supplemental activity to the current curriculum or some may wish to rewrite part or the entire curriculum to integrate research into the entire summer instructional component.

With 40 years of success linking pre-K-12 programs with higher education and graduate degrees, the Trio Programs are models for all that we do today in the field. The Upward Bound Math and Science program focuses on first generation, low-income college students, providing academic enrichment throughout the year as well as an intensive 6-week program each summer while the student is in high school, in order to prepare the student to enter college.

The two federally mandated criteria of participant eligibility are low-income and potential first-generation-college student status. The U.S. Department of Education defines a low-income individual as an individual whose taxable income did not exceed 150 percent of the poverty level amount in the calendar year preceding the year in which the individual initially participates in the project. The percent of persons with a household income of less than \$25,000 in 1999: 30.5% for Pennsylvania and 28.6% for the United States (as reported in the US Bureau of the Census, Current Population Reports, 2000).

The second criterion of participant eligibility is potential first-generation-college status, which exist for an individual neither of whose natural or adoptive parents received a Bachelor's degree or, who prior to the age of 18, regularly resided with and received support from only one natural or adoptive parent and whose supporting parent did not receive a Bachelor's degree. With a state average of 77.6%, each of the target school communities has a higher percentage of their populations without a Bachelor's degree than the state. Also, Pennsylvania's percent of individuals not holding a Bachelor's degree is also greater than the national average of 75.5%.

The Penn State Upward Bound Math and Science Program's students are primarily from Harrisburg, Reading, Philadelphia and Pittsburgh. The Upward Bound Math and Science program is aligned with state academic standards, developmental and provides broad based concepts and fundamental skills. However, students who participate state wide in all Trio programs and any eligible resident of Pennsylvania are welcome to apply to the Upward Bound Math and Science Program. The core demographics demonstrating the success of the program:

- 94% of the served students are under-represented group members.
- 100% of the Upward Bound Math and Science students are accepted to college
- 98% graduate from college
- 83% graduate from math, science and/or technical disciplines

The Pennsylvania State University (Penn State) Upward Bound Math and Science Center services needy students in the broad geographic area of Pennsylvania. The strong need within the state of Pennsylvania for a Upward Bound Math and Science Center continues to be evident in the large pockets of poverty and meager support for education that prevail. This need is glaringly obvious in the schools' minimum analytical/technical course offerings, obsolete equipment, deteriorating science laboratories, insufficient access to computer equipment, few guidance counselors to serve large numbers of students, dearth of opportunities for students to learn about educational paths to careers in the fields of math and science, along with students' poor academic performance and progress. The target schools the Upward Bound Math and Science Center are:

- Harrisburg, PA – **Harrisburg High School** (Dauphin County)
- Reading, PA – **Reading High School** (Berks County)
- Philadelphia, PA – **Germantown High School** and **William Penn High School** (Philadelphia County)

In addition, the program recruits from Pennsylvania TRIO pre-collegiate programs and plans to work collaboratively with the Migrant Education Centers in Philadelphia and Reading. Few of the students in these schools will successfully complete secondary education with the skills to pursue the education necessary for a career in math and science without the enhanced educational services provided by this Center. Regarding coursework, the four target schools again have minimal offerings and cannot adequately prepare students to be competitive in preparing for postsecondary math, science, and engineering studies. The limitations on course offerings derive primarily from the poverty of the school districts. Few schools are able to offer Pre-Algebra, Elementary Functions, Introduction to Calculus, Advanced Geometry, and Computer courses in the mathematics area. In the science area, few schools are able to offer Science and Technology, Botany, Ecology, Biochemistry, Engineering, and Advanced Science and Laboratory courses.

Among the large group of eligible students from the target schools and from Upward Bound and Talent Search programs across the state, there are significant numbers of students who have demonstrated interest and capacity to pursue academic programs that lead to careers in math and science. A survey was conducted at each target school regarding student interest. The survey was administered to students enrolled in college preparatory math and science courses in the ninth, tenth and eleventh grades. Since the college preparatory students were given the survey,

the capacity was assumed to be 50%--a low estimate. From the data, the numbers of students who are eligible interested and have the capacity to pursue academic programs in math and science was calculated by multiplying the number of students by each of the percentages.

The SEEMS program utilizes a tried and true approach to experiential learning and engagement through activity. However, the question, why integrate a research experience into a math and science enrichment program may continue to linger. There are benefits for all involved with little to no negative impacts.

For the College, the benefits outweigh any costs. The disciplines housed in the College of Earth and Mineral Sciences at Penn State are unique. There is no other college like EMS in the country. Under one roof, we have social sciences (Geography and Energy Business and Finance), physical sciences (Meteorology and Industrial Health and Safety), and engineering (Mining Engineering, Petroleum and Natural Gas Engineering, Environmental Systems Engineering, and Materials Science and Engineering), in one college with a focus on the environment, energy, materials, people, places and the atmosphere. The majors and resulting career paths are uncommon and all too often go unknown particularly among underrepresented populations. Having never known a mining engineer, a geoscientist or a geographer, few students knowing select these disciplines as an undergraduate major. We refer to ourselves as a "discovery college." Translation, you only discover us through a contact or prior knowledge. SEEMS has allowed us to infuse new talent into our programs. The results of working with the Upward Bound Math and Science Program are measurable. Of the 7 Upward Bound Math and Science students who entered Penn State summer or fall 2004, 3 are in the College of Earth and Mineral Sciences and all 3 have maintained mentoring relationships with the faculty who directed their research experience.

The Upward Bound Math and Science Center provides a richness and depth of data about potential students, their home communities and assessment. The Upward Bound Math and Science Program's attention to measurable results and data collections provides an ideal link for our research oriented faculty. The program collects and maintains longitudinal data on their participants. This also enables the College to add some new assessments to the program, the math language survey for example. Linking a summer enrichment program into the research of the College, the life of the College, adds a new dimension for both the Upward Bound Math and Science students and the faculty. There is crossover as well with our undergraduate summer research experiences (SROP), BRIE, CEKA, and MRSEC). The experience for all has broadened borders and horizons. Laboratory collaboration between international graduate students, undergraduates from HBCUs and HSIs, Pennsylvania high school students and college faculty and staff indeed change the way they each see not only the research enterprise but also the world. A hands-on experience in Mining Engineering focusing on Bio-Terrorism, using underground tunnels as simulations for subway tunnels, suddenly makes the field real and relevant in a world of BET, MTV, video games and television drama. Discovery of potential majors and career paths is pushed into the pre-college experience rather than the undergraduate experience. This encourages the need for preparation during high school as well as access to additional resources in making college decisions.

Quite rapidly, the faculty begins to view the Upward Bound Math and Science students as “their students.” Imagine a department head sending an email to the Program Director proclaiming that the students are overworked with classroom assignments as well as laboratory expectations! Or imagine receiving the following in an email at the end of week one from a member of the Meteorology faculty, "The kids are pretty overwhelming too. They're about as well prepared to organize and execute research as a good bunch of beginning M.S. students. That's an amazing suite of abilities for a trio of 18 year-olds. The training the got prior to this year must be second to none." The students he is referring to are low income, first generation college students who attend public high schools. This is more than a stone in the pond toward changing the landscape to being more inclusive and welcoming. These are members of the graduate research faculty who in turn, stay in touch with "their students", advising them through roommate issues, including them in additional research and then providing links from their homepages to research mentoring, showcasing their research teams and the Upward Bound Math and Science students.

For the Upward Bound Math and Science program, the program enables them to meet the academic needs of an increasingly diverse TRIO population. Supplying not only a rich out-of-the-classroom experience, but highlighting potentially high paying career paths. The program has a demonstrated relationship with an academic college. The relevance of the research process in higher education and in industry is made clear to the participants. Working in a lab and studying polymer science becomes more when the students are producing bouncing balls, using math, physics and chemistry to not only change the color of the balls, but the bounce. The experiences highlight linkages between theory and practice. It encourages more inquiry based learning, allowing the teachers to change their teaching as usual. And it provides opportunity for cooperative learning. The experience of each research group extends beyond the group.

In this integrated model, the core classes are based on developmental competency mastery. Research component blended into core class content allowing discussion, practice and integration to occur in multiple environments. The program is dependent on college and department cooperation. Research is more related to core classes, and in 2005 will be developmental driven. Research projects are related to each other and operate on the same timeline. A wealth of expertise on every topic is offered by the faculty, staff and graduate students to the Upward Bound Math and Science program, the teachers and the students.

The process for initiating the program begins with research experiences solicited through the department heads, directors of the research institutes and individual faculty. The request to the 5 departments of the College is to provide faculty directed hands-on research experiences for high school students. In the summer of 2003, we piloted a research component of the 6-week residential program, bringing the 50 high school students into laboratories and research centers for 27 hours, over the span of 5 weeks. This additional component is outside the classroom instruction, which is core to the program: math, computing, communications and science, with the 9 teachers focusing on applications based on the research experience.

These students, entering 10th through 12 grades in the fall, were divided into research teams working in faculty developed and directed experiences. The Upward Bound Math and Science tutor/counselors and the teachers attend the research sessions with the students. The teachers can then apply their expertise to the research experience in the Upward Bound Math and Science

classrooms as well as in their home schools. The research topics were as varied as the disciplines and faculty of our College. Faculty were encouraged not to create new projects. However, investment was great, resulting in more than one team exploring the same problem using different methods, creation of computer programs to support the student research and development of completely new experiences. Through the support of the Dean, a small stipend was provided for a graduate assistant to aid in each research experience. Grant funding now supports graduate student participation.

The base model for the program is the Center for Institutional Cooperation's Summer Research Opportunities Program, which is a mentored one-one-one research experience, including professional development workshops and a formal research presentation. At the conclusion of the SEEMS experience, the participants presented their findings in a formal research forum, in a team format, judged by faculty, the College leadership and University administrators. There is a large audience including the involved faculty, graduate students, staff, other Trio program staff, program alums and even a few parents. The student teams provide the judges and audience with abstracts. The format is a group presentation. The students complete a 15-minute presentation, using PowerPoint and visual aids. The top 4 teams receive awards. Each student is required to write individual research papers, and to keep a reflection journal of the experience.

Integrating a research experience into the Upward Bound Math and Science Program has been a success for the College, the program and the students. For the College, we have recruited bright, new students into our undergraduate program. We have a summer and year round program that is successful and manageable. We have multiple contacts with the same students over the course of a year. We have been able to identify faculty who are not only willing to be involved but are excited to be. We have received grants and corporate dollars not only to support the program but to enhance it with elements of parental involvement and career seminars. For the Upward Bound Math and Science Program, additional funding has allowed increased participation in the year round program as well as program enrichment. The relationship with the College has provided a wealth of expertise to the program.

For the Upward Bound Math and Science students, they have gained confidence about themselves and their intellectual abilities. Their growth through the research experience and expertise has allowed competition in science fairs and events. The mentoring they have received from the faculty and graduate students, who have shown a genuine interest in their success, has prepared them for their next stage in life. The participants have gained access to scholarship dollars that they might have otherwise by-passed.

As we prepare for our third summer, the number of faculty who wish to participate is greater than the number of students we have. The teachers and Upward Bound Math and Science staff will again alter their core curriculum to mirror and support the research experience. The College will provide information of the research experiences in advance to allow the teachers to develop their lessons to support the experience, a true integration. There will be an on-line group for all faculty, staff and students participating in SEEMS, which will include a developmental evaluation for the experiences. Corporate sponsorship and grants has allowed new educational materials to be added to the core as well as programmatic content. Preparation materials for the new SAT, as well as "*Style for Students: Effective Technical Writing in the Information Age*," by

Joe Schall, will be provided through external support. The participation of 10 students in the Upward Bound Math and Science program this year is made possible by AESEDA (Alliance for Earth Science Engineering and Development in Africa, an EMS research initiative) and corporate gifts.

SEEMS has been a win-win-win, for the College of Earth and Mineral Sciences, for the Upward Bound Math and Science Program and for all participants. This partnership is far more than an outreach program and has given unexpected benefits, both direct and in-direct. The sense of a community that has grown through the interactions of the students and the College community extends beyond the lines of the University, including those who have all too often have remained outside the opportunity of higher education. There is great potential for growth in this program, and programs like it. Upward Bound Math and Science and other Trio programs, offer community based k-12 programs that higher education cannot access alone, let alone the history of success. The newly proposed federal budget zeros out Trio Programs Talent Search and Upward Bound by summer 2006 to support the 9-12 portion of No Child Left Behind legislation. In an effort to leave no child behind, thousands of high school students, who are first generation, low income, many who attend failing schools will not only be left behind, but left out without resources, support and guidance into post-secondary education. Success should build replication not elimination. The price that America and all Americans will be paying is indeed too high.

Additional data available at the WEPAN/NAMEPA Joint Conference:

- Penn State Upward Bound Math and Science Target Area
- Standardized achievement tests given at target schools
- Target area averages of student performance on the Scholastic Assessment Test
- Resources available at target area schools
- Math courses offered in target area high schools
- Science courses offered in target area high schools
- Eligible students interest and capacity in math and science
- Pre-Experience Questionnaire
- Math Language Survey
- Overview of the Upward Bound Math and Science Program (Summer Session)
- Research Experiences 2003 and 2004
- Post Experience Questionnaire
- Upward Bound Math and Science Center Calendar of Activities