COMMENTARY

A Critical Analysis of Faculty-Developed Urban K-12 Science Outreach Programs

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INTRODUCTION

Urban schools across the United States are confronted by the same complex social and economic problems that afflict the communities that they serve (Ladson-Billings, 2008). We have observed that teachers in urban areas often have very low expectations for their students, and the enacted science curriculum is poorly delivered and lacks coherent flow (Prime & Miranda, 2006). There is extensive research that provides evidence that urban schools are under-resourced, woefully underachieving, and populated largely by minority students who live in disadvantageous economic circumstances (Darling-Hammond, 2007; Ladson-Billings, 2006; Seiler, 2001). Additionally, research has shown that significant science achievement gaps between minority and majority students have not narrowed from 1996 to 2005 (National Center for Educational Statistics, 2006). These gaps have been coupled with complex factors such as race, ethnicity, immigration patterns and socioeconomic status (Norman, Ault, Bentz & Meskimen, 2001). Based on our anecdotal evidence, we believe that the often lamented problem of underachievement in urban schools can be largely viewed as a problem of the underachievement of poor, minority students.

To address these complex socioeconomic issues, higher education faculty are currently involved in developing and facilitating science outreach programs that specifically target K-12 students and teachers in urban school (Bartel, Krasny & Harrison, 2003). However faculty developers of K-12 science outreach programs, who are funded through various funding agencies, have little background in educational outreach or in urban school settings (Krasny, 2005). Additionally, after reviewing the extant literature, we have realized that there is scant evidence of well-documented science outreach programs developed by higher education faculty targeting K-12 students and teachers in urban school settings. Given the availability of external funding aimed at addressing low science achievement in urban schools, it is clear that institutions of higher education are engaged in outreach programs. However, we have observed that little information about these programs has made its way into published science education literature. Hence, a more comprehensive understanding of the extent of these programs is vital for individuals who are interested in developing urban science outreach programs. This is especially true in light of our current need to respond to socioeconomic problems impacting the urban K-12 school settings.

Accordingly, the purpose of this paper is twofold. First, we provide an overview and critically analyze three successful faculty-developed urban K-12 science outreach programs. We consider a successful outreach program as one that has been sustained for at least five years after initial funding, and has provided empirically-based research findings from the program. Additionally, we review each program from the following three vantage points: 1) broader impacts on students and teachers, 2) program structure for participants, and 3) program assessment. Second, we offer recommendations to help guide other higher education faculty interested in developing K-12 science outreach programs in urban settings. More specifically, this article sought to determine answers to the following questions:

1. What are the broader impacts of faculty-developed K-12 science outreach programs on teachers and students in urban school settings?
2. How are faculty-developed K-12 science outreach programs structured specifically for teachers and students in urban school settings?
3. How are faculty-developed urban K-12 science outreach programs assessed?

OVERVIEW AND CRITICAL ANALYSIS

Since its inception in 1991, the University of Arkansas for Medical Sciences (UAMS) has facilitated the nationally recognized science outreach program called Partners in Health Sciences (PIHS) in collaboration with the Arkansas Department of Education and the University of Arkansas at Little Rock (Burns, 2002). All public and private K-12 teachers and their students in the state of Arkansas are invited to participate in this program for free. The program was institutionalized through funding from two separate 5-year National Institutes of Health Science Education Partnership Award grants. After ten years, the PIHS program has reported broader impacts on a total of 1,052 teachers and 11,402 students, and involved 143 UAMS faculty.

K-12 teachers participating in the PIHS program primarily receive professional development training. Several 1-3, full day mini-courses are offered during the summer to biology/health sciences teachers. Each mini-course is developed and presented by a UAMS faculty member on a specific topic through an interactive lecture and discussion format, and is followed by hands-on laboratory exercises. As an incentive, teachers receive a tool kit containing materials and supplies necessary to conduct these laboratory exercises with their own students. Additionally, teachers are awarded continuing education credit for each mini-course they complete, and can earn college credit if they complete a total of 5 full days of mini-courses. Furthermore, 10 teachers (Grades 7-12) are selected each year and given stipends to participate in a 5 full-day workshop to develop grade appropriate computer assisted instructional (CAI) modules for use by their students.

Students (Grades 7-12) participating in the PIHS program partake in weekly, interactive, 90-minute broadcasts during the academic year with UAMS faculty. These students are further encouraged to tour the UAMS facilities, and to attend *monthly science nights* to listen to various speakers, in order to expose them to different careers in health sciences.

Surveys were conducted to assess the UAMS speakers, the use of good audio-visuals during presentations, the effectiveness of laboratory activities, the amount of time provided for questions, and future interests of participants. Additionally, surveys were administered to determine whether teachers implemented new professional development training activities with students in their classrooms. Questionnaires were further employed to obtain demographic information of all participating teachers and students.

We believe that a major strength of the PIHS program is the facilitation of a needs-assessment with members from the Arkansas Science Teachers' Association. This vital feedback helps higher education faculty to tailor their presentations to the specific needs and interests of K-12 teachers. We also consider another strong point to be that all program activities were developed by highly-credentialed UAMS faculty members who specialize in the specific science content area presented. Moreover, we posit that the PIHS program has made some significant broader impacts on minority teachers and students. This is substantiated by surveys results that show that 44% of teachers earning college credits were minorities, and that the percentage of minority students participating in broadcasts and *monthly science nights* were 22% and 63%, respectively.

We believe that a significant limitation of the PIHS program is that teachers were not provided with adequate on-site support to ensure that the professional development activities were successfully transferred in their classroom. This is quite evident from survey results that reveal that 46% of teachers self-reported that they did not perform any new laboratory-type exercises with their students. We also think that UAMS faculty placed an emphasis on traditional teaching formats such as interactive lecture and discussion. Thus, faculty should consider collaborating with science education specialists to incorporate more inquiry-based teaching approaches into their presentations. This is apparent from results from the questionnaire results that indicate that the percentage of minority teachers participating in all mini-courses, and CAI workshops were only 15% and 6%, respectively. Additionally, we believe that faculty should conduct a needs-assessment to determine science topics that minority teachers and students are most interested in. This strategy may have promise in light of questionnaire results that show that the percentage of minority teachers attending the culturally relevant mini-course entitled, "Blood and Sickle Cell Anemia," was 25%. Moreover, we consider some shortcomings of the program to be that only 9% of participating teachers were from elementary schools (Grades K-6), and that only middle and high school students were allowed to participate in program activities. Based on the above data, we conclude that the PIHS program tended to concentrate their outreach effort toward middle and high school students (Grades 7-12).

Buffalo Geosciences Program

Since its inception in 2001, the University of New York at Buffalo has facilitated the urban K-12 science outreach program called the Buffalo Geosciences Program (BGP) in collaboration with Buffalo State College and the City Campus of Erie Community College (Stokes, Baker, Briner, & Dorsey, 2007). This program was created to: 1) provide opportunities for underrepresented groups to participate in geoscience activities, 2) to pursue undergraduate/graduate degrees in geosciences, and 3) to enter geoscience careers. The BGP was institutionalized through funding from a 5-year National Science Foundation Opportunities for Enhancing Diversity in the Geosciences grant. After 5 years, the BGP reported impact on a total of 189 teachers and 5,215 students, and involved 68 university faculty members.

Participating high school students in the BGP complete an Earth Science course, partake in outreach efforts in their school and the community, design geoscience activities for summer camps, assist university faculty and graduate students with research projects, and attend field trips and seminars. Interested high school students can also serve as interns and receive funding to develop and pursue their own research ideas based on existing projects at the university. Students in elementary and middle schools receive outreach presentations to generate interest and create awareness in the geosciences. Presentations for K-12 students generally include two modules. The first module engages them in a lecture and discussion format about geoscience topics relating to current events; the second module provides students with information about careers in the geosciences. High school teachers participating in the BGP primarily receive geoscience-themed literature and training on challenging geoscience concepts.

Surveys were conducted to assess the broadening of participation and to determine high school students' improved awareness of geosciences, and increased interest in geosciences careers, and knowledge of geosciences issues. We believe that a significant strength of the BGP is that students can develop and facilitate their own research projects under the supervision of highly-credentialed university faculty, and graduate students. Based on survey results, we further posit that the BGP has made considerable broader impacts on teachers and students in urban K-12 school settings.

We consider the limited role of high school teachers in the BGP to be a critical shortcoming. University faculty should thus consider collaborating with teachers or science education specialists to incorporate more inquiry-based teaching approaches into their presentations rather than emphasizing a traditional lecture and discussion format. We also believe that some significant limitations of the BGP is that the activities and presentations intended for elementary and middle schools were limited in scope and were not specifically differentiated for various grade levels or student abilities.

Progressive 3-Year Summer Science Institute

Since its inception in 2000, the University of Alabama's Birmingham Center for Community OutReach Development (UAB CORD) has facilitated an urban science outreach program that centers on a progressive 3-Year Summer Science Institute for high school students (Niemann, Miller, and Davis, 2004). The program's objectives are to: 1) interest students in pursuing careers in science, 2) give students a better idea of what it is like to do real science, and 3) teach students science-related skills. This program was developed in collaboration with the Birmingham City School System, and institutionalized through funding from the National Institutes of Health Science Education Partnership Award grant, the National Science Foundation GK-12 grant, the Robert Wood Johnson Foundation, and philanthropists, Holt and Gretchen Cloud. After 3 years, the program reported broader impacts on more than 200 students. It also involved faculty, graduate students, and staff from UAB CORD, and trained high school science teacher facilitators.

Rising 10th grade students are introduced to basic concepts and laboratory skills in a 6-week BioTeach Summer Science Institute. Rising 11th grade students are gradually introduced to increasingly more rigorous concepts and laboratory experiences in a 6-week ChemTeach Summer Science Institute. Rising 12th grade students serve as interns and conduct a research project that is supervised by UAB faculty, graduate students, and staff for 9-weeks. Additionally, all participating students were exposed to scientific seminars by UAB experts in the field, university tours, debates on moral and ethical scientific issues, and Mathematics and English Workshops. All students received stipends after they complete each Summer Science Institute.

High school teachers participating in the program are exposed to the nature of science, and concepts of authentic scientific research. Teachers also receive training to learn how to become facilitators of UAB CORD's Summer Science Institute Programs, which include BioTeach, ChemTeach, and Research Internships for Students. Surveys were administered to determine whether: 1) students learned science, 2) students are better prepared for college science, 3) the program provided students with a better idea of what it is like to do real science, and 4) students learned other useful life skills. Other components of the program that were evaluated through surveys include students' suggestions for improving the program, the effectiveness of Mathematics and English Workshops, and the training of high school science teacher facilitators.

We consider the main strength of this program to be the criterion for accepting students for the program. The major acceptance criteria for this program are that students have to demonstrate an interest and aptitude for science. This is substantiated by teacher recommendations, course selection and grades, extracurricular activities, and an interview. We also believe that this criteria and the involvement of UAB's Office of Minority Recruitment and Retention helps to provide an explanation for the high retention rate of inner-city high school students participating in this program.

We consider a shortcoming of the program to be the over-emphasis of teaching formats which include lectures, laboratory lectures, and scientific seminars. It is no surprise that participating students responded that these teaching formats were their least enjoyable component of the program. Faculty should collaborate with science education specialists to incorporate other inquiry-based teaching strategies into their presentations.

DISCUSSION AND CONCLUSION

This paper provides an overview and analysis of three successful faculty-developed urban K-12 science outreach programs from the following three vantage points: 1) broader impacts on students and teachers, 2) program structure for participants, and 3) program assessment. Through the findings of this paper, and our experiences and responsibilities as directors of grant-funded urban K-12 science outreach programs, we believe that we can offer specific recommendations to help guide other higher education faculty that are interested in developing their own programs.

Regarding the broader impacts on K-12 students in urban settings, it is apparent that many outreach programs tend to concentrate their outreach effort on middle and high school students. However, research suggests that science outreach programs that engage elementary students in hands-on laboratory activities have positive impacts on their attitudes toward science (LaRiviere, Miller, & Millard, 2007). We concur with this research finding and recommend that faculty developers bolster their programmatic involvement in early childhood and elementary education. We believe that this is essential to further broaden opportunities for urban students across all grade levels. We also advise that faculty developers should collaborate with science education specialists to help differentiate their programs for various grade levels and varying levels of student ability, and to incorporate more inquiry-based teaching approaches into their presentations. Since scientists do not typically have any formal pedagogical instruction, science educators are able to provide them with practical guidance especially in learning by inquiry, cognitive development, and misconception research (Zitzewitz, Moyer, Otto, & Everett, 2010).

It is also evident that outreach programs are still needed to encourage diversity, broaden opportunities, and enable the participation of women, underrepresented minorities and persons with disabilities. Our view is substantiated by reports that indicate that number of science and engineering degrees earned by minority and female students is disproportionately low in comparison to the national average (National Science Foundation, 2006). In light of this, we suggest that faculty developers should consider augmenting their programmatic involvement with these populations of K-12 students in urban school settings. It is further noticeable that urban K-12 science outreach programs do not specifically address our current workforce needs in science, technology, engineering, and mathematics (STEM) education (National Academy of Science, 2007). Therefore, we advocate that faculty developers design science outreach programs that seek to expose and engage students to careers in STEM teaching.

Findings and Recommendations

This article demonstrates that some outreach programs do not provide adequate on-site support for teachers in their classrooms. In our experience with facilitating professional development with in-service K-12 teachers, this kind of support is critical to ensure that outreach activities are effectively implemented. Accordingly, we suggest that faculty developers should conduct a needs-assessment with teachers to determine the specific level of support and resources necessary for effective implementation of outreach activities in their science classrooms.

We also recommend that faculty developers provide program facilitators with training that focuses on planning and developing culturally relevant inquiry-based science lessons, and teaching effectively in urban K-12 school settings. This recommendation is in line with sociocultural dimensions of teaching which identifies the need for more culturally responsive teachers in urban settings (Duarte & Reed, 2004), and seminal research which has shown that teaching through a sociocultural approach has a positive effect on students' attitudes toward learning science (Jegede & Okebukola, 1991). Further, we suggest that faculty developers adequately: 1) assess the needs of urban K-12 students, teachers and schools, 2) align program goals with the school's improvement plan and teachers' professional improvement plan, and 3) link program topics with the science curricula of the school, and local and national science education standards.

Another significant finding of this study is that although developing and facilitating urban K-12 science outreach programs makes a great deal of intuitive sense, it generally lacks empirical validation. When conducting the literature review for this article, we found it rather difficult to find outreach programs that provided clearly articulated research questions, or specific details with regard to how programmatic data and goals can be collected, analyzed, and accomplished. This finding clearly demonstrates the inherent difficulty in determining the overall success and effectiveness of urban K-12 science outreach programs, since many programs within the literature often present their outcomes anecdotally. Thus, based on our background as science education research faculty members, we encourage faculty developers to provide adequate detail with regard to how program goals are to be assessed, and to share their programmatic findings with the STEM community through conferences, research and practitioner journals, and popular publications so that they can be used as a basis for discussion. We further encourage faculty developers to take a more critical, empirically-based research perspective in their outreach efforts.

As faculty-developed urban K-12 science outreach programs begin to proliferate and flourish, it is essential for institutions of higher education to effectively forge collaborations with urban K-12 school settings to ensure that minority students in public schools receive a high quality science education. While many higher education faculty are already successfully engaged in outreach activities with K-12 students and teachers in urban schools settings, a salient trend within the extant literature is that faculty-developed urban science outreach programs are generally unidirectional (e.g. Chan & Flinn, 2005; Hunter, 2006; Kindlund & Boshart, 1998; Munn, Skinner, Conn, Horsma & Gregory, 1999). Thus, we recommend that faculty developers become more collaborative and bi-directional in their goals and activities. This recommendation is in line with Tanner, Chatman, and Allen (2003) who suggest that science outreach programs are specifically poised to blossom into partnerships in which higher education faculty and K-12 school settings collaborate to create a coherent and articulated science education experience for students and teachers. In view of this, the establishment of partnerships between higher education faculty and urban K-12 school settings imply something more than an instructional relationship based on a one-way flow of information. The construct of "partnership" implies direct benefit for all parties involved, and involves two or more people, each with expertise or skills to contribute, working toward a common goal (Tomanek, 2005). Hence, we further advise that faculty developers actively involve all key stakeholders in the strategic planning process to help identify how all partners can benefit and work together towards developing, achieving, and assessing program goals.

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