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# Development, Evaluation, and Dissemination of an Astrobiology Curriculum for Secondary Students: Establishing a Successful Model for Increasing the Use of Scientific Data by Underrepresented Students.

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**Abstract.** The Minority Institution Astrobiology Collaborative began working with the NASA Goddard Center for Astrobiology in 2003 to develop curriculum materials for high school chemistry and Earth science classes based on astrobiology concepts. The Astrobiology in Secondary Classrooms modules are being developed to emphasize interdisciplinary connections in astronomy, biology, chemistry, geoscience, physics, mathematics, and ethics through hands-on activities that address national educational standards. Since this time, more NASA Astrobiology Institute Teams have joined this education and public outreach (EPO)effort. Field-testing of the Astrobiology in Secondary Classrooms materials began in 2007 in five US locations, each with populations that are underrepresented in the career fields of science, technology, engineering, and mathematics.

## 1. Introduction

The intent of the Astrobiology in Secondary Classrooms (ASC) project is to establish a successful model for creating the scientists of tomorrow by bringing powerful technology tools and current scientific data into an interdisciplinary curriculum focused on reaching all students. Goals for students participating in the ASC curriculum in their classrooms include:

- An understanding of the research pursuits and findings of key astrobiology researchers
- An appreciation for scientific research and the current knowledge base available in astrobiology
- A high degree of scientific and technological literacy
- A desire to continue their studies in STEM areas, particularly in areas pertaining to astrobiology

The ASC curriculum tackles many of the current problems in science education by addressing curriculum issues as well as minimizing classroom limitations that affect science instruction, particularly in classrooms containing high numbers of students underrepresented in science careers. Many science curricula, including textbooks, lack connections among different academic disciplines and do not provide students with a coherent framework for both science literacy and content knowledge. The ASC modules are being developed using research-based teaching strategies designed to diminish achievement gaps and increase the participation of underrepresented groups in science, technology, engineering, and mathematics (STEM).The ASC project began in 2003 with a team of university faculty from minority serving institutions and teachers selected by members of the Minority Institution Astrobiology Collaborative (MIAC). Working with scientists at the Goddard Center for Astrobiology, the team developed the ASC curriculum framework. Now, through this network of minority-serving institutions, the ASC staff seeks to enable middle and high school teachers across the United States to include astrobiology-related activities in their classrooms. Major partners during the field-testing phase of the materials are sites designated as NASA Science, Engineering, Mathematics and Aerospace Academies (SEMAA). Partnerships with SEMAA programs and other minority serving locations allow for a focus on diversity when field-testing and developing the ASC curriculum in both formal and informal educational settings. There are currently field-testing sites in five different locations where more than 80 percent of the students are members of the Native American, African American, or Hispanic American communities.

## 2. Discussion

Research supports the use of astrobiology as a framework for increasing science literacy (Astrobiology Design Project Team, 2002; Carrapiço, et al. 2001; Rodrigues & Carrapiço, 2005; Slater, 2006; Staley, 2003; Tang, 2005) because of its interdisciplinary nature. Furthermore, partnerships between curriculum developers, teachers, professional scientists and NASA researchers will provide the "real-world" contexts that are recognized as a vital part of science literacy and increasing student interest and understanding of STEM areas.The pedagogical side of the ASC curriculum has been grounded in three evidenced-based practices shown to increase achievement among all students and specifically among ethnically diverse students:

1. The *Five Standards for Effective Pedagogy* developed by the Center for Research on Education Diversity and Excellence (CREDE) provide a framework for culturally relevant instruction (Tharp, et al., 2003). The ASC Curriculum incorporates these principles in each of the modules in recognition of the importance of cultural awareness and the dynamics of learning in diverse settings (Lee & Luykx, 2006; Aikenhead, 2001; Lynch, et al., 2005).

2. The ASC Curriculum includes differentiated instruction that provides teachers with strategies for scaffolding that is a necessary part of effective teaching with varying levels of prior knowledge and understanding.

3. Civic Capacity is a principle whereby engaging students in community and through meaningful partnerships, academic enrichment can have significant and long-lasting effects. In their work with the NSF funded VISIT Teacher Enhancement Project, Hunter and Xie (2001) detailed the barriers for teachers accessing and using the vast amounts of data on the Internet. The ASC project will partner curriculum developers and teachers with astrobiology researchers to develop scientific data sets that are user-friendly in the high school classroom as well as provide much needed materials and laboratory supplies in order to overcome these barriers.

## 3. Program Evaluation

Evaluation of the ASC curriculum is in progress and includes iterative evaluation and implementation to modify modules. In the 2006 ASC teacher workshop held at Tennessee State University, 14 teachers were given pre-surveys, post-evaluations, and were asked to submit recommendations and participate in exit interviews. The surveys and evaluations used a Likert scale of 1 (poor) to 4 (excellent). Teachers scored the following items highly: workshop content, presentations by scientists, encouraging use of hands-on activities, and their perceived increase in knowledge about astrobiology. In fact, when rating the scientific content embedded in the ASC modules, 13 of the 14 teachers rated the activities as excellent (Table 1).

Table 1. Mean ratings for teacher response questionnaire statements by question type (N=14)

| | |
|---|---|
| Use of technology: spectroscope and spectrometer | 3.69 |
| Biology and extremophile activities | 3.92 |
| Chemistry activities as they relate to astrobiology | 3.92 |
| Physics and astronomy activities including field trip to Dyer Observatory | 3.92 |
| Earth science activities analyzing rock samples collected on the geology fieldtrip | 3.62 |

ASC modules were field tested in the 2006 high school SEMAA session at TSU. Students were asked to rank the activities they recommended as part of future SEMAA programs. Sixty percent (60%) indicated they would like

to participate in astrobiology activities; Forty-seven percent (47%) indicated interest in activities concerning research in astronomy and the search for life in the universe. The 2007 SEMAA High School Summer Camp focused on the geoscience module of the ASC curriculum. Students completed a pre- and post-session survey using a Likert scale of 1 (poor) to 4 (excellent). Participants were asked about their interest levels in Earth science, engineering, space science, and general science as well as how much they felt they knew about technology uses in the geosciences, the importance of geoscience, and science/engineering careers. A paired sample $t$-test was used to calculate the significance of the mean differences in student responses from time 1 to time 2 in a single sample. These students reported a statistically significant increase in interest in space science, earth science, and engineering (Table 2).

Table 2. Mean ratings for student interest questionnaire statements by question type, paired t-test values, and probability (p) values

| Question | Mean | Std. Dev. | $N$Pairs | $t$-Value | $p$ |
|---|---|---|---|---|---|
| Space Science | | | | | |
| Pre-survey | 2.46 | 0.877 | 13 | -2.94 | 0.012* |
| Post-survey | 3.00 | 0.913 | | | |
| Earth Science | | | | | |
| Pre-survey | 2.54 | 1.05 | 13 | -2.89 | 0.014* |
| Post-survey | 3.15 | 0.80 | | | |
| Engineering | | | | | |
| Pre-survey | 3.08 | 0.669 | 13 | -2.57 | 0.026* |
| Post-survey | 3.58 | 0.515 | | | |

*Significance at the $p < .05$ level

Activities at the 2007 summer camp involved using hand-held reflectance spectrometers to analyze rocks, learning about resonant frequencies, and simulated missions to Mars while looking for signs of life. A paired sample $t$-test was used to calculate the mean differences in student responses from time 1 to time 2 in a single sample. These students reported a statistically significant increase in understanding the area of technology uses in science and technology uses in geoscience (Table 3).

## 4. Summary

The ASC modules will provide a web-based interdisciplinary curriculum in astrobiology that is free and easily accessible by the public. The curriculum is designed to supplement existing state curricula by providing a framework that draws together all areas of science through engaging activities, providing teachers with activities that meet both state and national standards along with encouraging science literacy. Accomplishing this goal will involve modification of modules based on feedback from teachers during professional development and implementation with students in formal and informal educational settings. Research during the field-testing phase of the project will assess the impact of these crosscutting activities on student performance and attitudes about science along with student interest in STEM careers. More information about

Table 3. Mean ratings for student knowledge questionnaire statements by question type, paired t-test values, and probability (p) values

| Question | Mean | Std. Dev. | *N* Pairs | *t*-Value | *p* |
|---|---|---|---|---|---|
| Technology In Science | | | | | |
| Pre-survey | 3.00 | 0.95 | 13 | -2.80 | 0.017* |
| Post-survey | 3.42 | 0.67 | | | |
| Technology In Geoscience | | | | | |
| Pre-survey | 2.38 | 1.04 | 13 | -2.25 | 0.044* |
| Post-survey | 3.08 | 0.49 | | | |
| Careers in the Geosciences | | | | | |
| Pre-survey | 1.85 | 0.80 | 13 | -2.67 | 0.020* |
| Post-survey | 2.69 | 0.947 | | | |

*Significance at the $p < .05$ level

the ASC project is available at www.astroclassroom.org, the SEMAA program website can be found at www.semaa.net, and the MIAC website is located at www.miacnetwork.org.

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