A Coral Reef as an Analogical Model To Promote Collaborative Learning on **Cultural & Ethnic Diversity in Science**

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A word search of the *National Science Education Standards* found that the term *diversity* appears 17 times, and within that publication the textual meaning is almost evenly divided between diversity of the student population and student needs and biological diversity. Program Standard A (coherence and consistency) and Program Standard B (curriculum) specifically state "All dimensions of a science program adhere to the principle of science for all. Themes and topics chosen or curricula should support the premise that men and women of diverse backgrounds engage in and participate in science and have done so throughout history" (*National Science Education Standards*, 1996).

Merriam-Webster defines diversity as "the condition of being diverse [variety]" (*Merriam-Webster Online*, 2006). However the word *diversity* has a more specific meaning that is dependent upon the context in which it is used, scientifically or culturally. For example, Biology-Online.org defines biological diversity in terms of ecology as "the number and variety of species present in an area and their spatial distribution" and cultural diversity as the "coexistence of numerous distinct ethnic, racial, religious, or cultural groups." In conversation, in the workplace, and in many official documents, diversity often compasses class, ethnicity, gender, age, sexual orientation, or the physical and mental ability of an individual (Wheeler et al., 1999).

Students often draw on past or related experiences to help them interpret new concepts. Through the use of analogs, learners are able to make certain assumptions which they use to help them understand new concepts (Goswami, 1991). In this situation, "something familiar stands in for something unfamiliar" (Petrosino, 2003). Analogy is also used in various situations involving deductive and inductive reasoning (Sowa & Majumdar, 2003). It is important to remember, however, that there is a risk that certain analogies or models may lead to student misconceptions (Frazier, 2002; Goswami, 1991). Thus, careful selection and discussion of analogies is important.

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Biological Diversity Exercise

We have noted that first semester college science students often fail to realize that individual scholarship is an intricate component of global scholarship, and that scientific advancements represent the scholarly contributions of many different individuals. In an effort to engage these students in critical thinking and active conversation about gender, diversity and ethnicity in science, a two-pronged approach was taken which used a naturally-occurring ecosystem, a coral reef, together with scientific biographical and historical references (Figure 1). This novel pedagogical approach also facilitates certain elements of student reasoning such as the consideration of multiple view points (Swartz & Swartz, 1983), synthesis of new ideas, and application and integration of knowledge (Wolcott & Gray, 2003; Foundation for Critical Thinking, 1996).

Before beginning the activity each student was randomly assigned a number that was entered on all collected materials. Next, the student's reasoning regarding diversity in the context of science was assessed by asking him/her to respond to the question: "What does diversity in the context of science mean to you?" The majority of students tended to show bias in their answers, which may be a reflection of how they have historically discussed diversity in other science classes. Typical of the individual responses were "Diversity in science means the different fields of science. It is having a firm hold on all kinds of science and being able to link them to other fields rather than just knowing about one particular field" or "differences in the ecosystem (animals, plants ...) –a wide variety of organisms, all different from each other in some way." After collecting the individual responses, the class was randomly divided into groups of four to six students. Each group was asked to synthesize a response to the same question. Since the group responses showed little variation from the individual responses, it was apparent that, even collectively, most students failed to recognize diversity in science as it relates to culture, race, ethnicity, and gender.

To facilitate class discussion on the topic of diversity, the students were given a collage of a coral reef. Following the same protocol, students first studied the collage individually and then moved into their assigned group. The reef was chosen for its visual impact and because it is an excellent model of diversity. It is a living system that many students have been exposed to through direct observation or media

Figure 1. Some examples of biographies, historical chronologies, and handbooks.

Asimov, I. (1982). *Asimov's Biographical Encyclopedia of Science and Technology: The Lives and Achievements of 1195 Great Scientists from Ancient Times to the Present Chronologically Arranged.* Garden City, NY: Doubleday.

Asimov, I. (1989). *Asimov's Chronology of Science and Discovery.* New York, NY: Harper & Row.

Bailey, M.J. (1994). *American Women in Science: A Biographical Dictionary.* Santa Barbara, CA: ABC-CLIO.

Bailey, M.J. (1998). *American Women in Science: 1950 to the Present: A Biographical Dictionary.* Santa Barbara, CA: ABC-CLIO.

Carney, J. E. (2001). *Renaissance and Reformation 1500-1620: A Biographical Dictionary.* Westport, CT: Greenwood Press.

Franck, I.M. & Brownstone, D.M. (1998). *Wilson Chronology of Women's Achievements from Ancient Times to Present.* New York, NY: H.W. Wilson.

Hellemans, A. (1988). *Timetables of Science: A Chronology of the Most Important People and Events in the History of Science.* New York, NY: Simon and Schuster.

Lyon, W.S. (1998). *Encyclopedia of Native American Shamanism Sacred Ceremonies of North American.* Santa Barbara, CA: ABC-CLIO.

Luck, S. (1999). *International Encyclopedia of Science and Technology.* New York, NY: Oxford University Press.

Mellersh, H.E.L. (1999). *Chronology of World History 1901-1998: The Modern World, Vol. 4.* Santa Barbara, CA: ABC-CLIO.

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Mellersh, H.E.L. (1999). *Chronology of World History: 1492-1775: The Expanding World, Vol. 2.* Santa Barbara, CA: ABC-CLIO.

Ogilvie, M.B. (1986). *Women in Science: Antiquity Through the Nineteenth Century: A Biographical Dictionary with Annotated Bibliography.* Cambridge, MA: MIT Press.

Proffitt, P. (1999). *Notable Women Scientists.* Detroit, MI: Gale Group.

Sammons, V.O. (1990). *Blacks in Science and Medicine.* New York, NY: Hemisphere Publishing Corp.

Schlessinger, B.S. (1996). *Who's Who of Nobel Prize Winners, 1901-1995.* Phoenix, AZ: Oryx Press.

Selin, H. (Ed.). (1997). *Encyclopedia of the History of Science, Technology, and Medicine in Non-Western Cultures.* Dordrecht; Boston, MA: Kluwer Academic.

Shearer, B.F. (1997). *Notable Women in the Physical Sciences: A Biographical Dictionary.* Westport, CT: Greenwood Press.

Storey, R.L. & Williams, N. (General Eds). (1973). *Chronology of the Medieval World: 800 to 1491.* New York, NY: D. McKay, Co.

Trager, J. (1992). *People's Chronology: A Year-By-Year Record of Human Events from Prehistory to the Present.* New York, NY: H. Holt.

Volti, R. (1999). *Facts on File Encyclopedia of Science, Technology and Society.* New York, NY: Facts on File.

Webster, R.B. (1999). *African American Firsts in Science & Technology.* Detroit, MI: Gale Group.

presentations. The collage consisted of seven pictures highlighting various aspects of life on a reef including different types of coral, fish, sea urchins, potential predator prey interactions, and a symbiotic relationship between a moray eel and a cleaner wrasse. After several minutes of studying the collage as individuals, the students were asked to describe what they saw. Most listed specific observations such as salt water, fish, coral, colors, and light. Somewhat surprisingly, they made no reference to the biological diversity that they described in their response to the initial question. To refocus the discussion on diversity specifically, a set of seven talking points was introduced. The students were asked as a group to take a fresh look at the collage and respond to each talking point. Some groups simply paraphrased the talking point, but others provided more complex answers reflective of a group activity. The facilitator then provided applications to the reef and to science (Table 1).

Cultural Diversity Exercise

Having engaged students in an analytical exercise in the exploration in biological diversity, the base, the next step involved migrating to the discovery of ideas and developments contributing to the medical sciences in the context of the global scholarly community, the target (Gentner, 1983). While remaining in their respective groups, students were provided library resources to enable the development of a chronology of significant contributions and practices in the field of medicine, and the identification of historical and contemporary scholars and practitioners by race, cultural heritage, and gender. The collective work of each group was noted on a whiteboard, running the full length of the classroom, to visually exemplify global scholarship over time.

The success of this innovative approach relied upon introducing an awareness of multiculturalism as well as the significant work of women, which contributed to the development of the medical sciences and required the identification of appropriate subject headings from prehistory to the present (Figure 2). Additional library materials consisted of general biographical references and historical chronologies with emphasis on the pure and applied sciences, while focusing special attention on works targeting those of minorities and women (Figure 1). Further consideration was given to works in technology for the purposes of including interdisciplinary contributions to the medical sciences. When combined, these resources facilitated elements of reasoning such as inference, implications, points of view, synthesis, and purpose by providing personal data, facts, observations, and experiences.

Each student received a unique reference work, and each group was then assigned responsibility for reviewing specific time periods in history: Prehistory to 799 AD; Medieval World 800-1491; Renaissance and Reformation 1500-1620; Changing World and Expansion 1770-1990; Modern World 1901-1946; and Post WWII to the present including Nobel Prize recipients (Figure 2). Each team member was asked to identify a different scientist or ethnic group within the given time period, and to provide the name, race, nationality, ethnicity, significant contribution and date, and source of the information. In order to facilitate student assumptions and observations, definitions from both a biological and sociological point of view for race and ethnicity were written on the whiteboard (Kuper & Kuper, 1996, pp. 260-261, 712; Oxford Dictionary, 2000, p. 444). As the vital statistics were acquired and written on the whiteboard, teams were instructed to conclude the exercise by indicating what they

Table 1. Student and facilitator responses to talking points on diversity.

Talking point	Representative Group Response (Students)	Application to the Reef (Facilitator)	Application to Science (Facilitator)
Does anything suggest harmony and balance are occurring?	There is a harmonious balance between the fish, the living reef, and the surrounding environment.	Interactions between the various organisms are required to maintain stability and balance; there may be keystone species, dominant species, and symbiotic relationships.	Interactions occur between scientists and laboratories via meetings, peer interactions, and publications; peer review and scientific method provide checks and balances.
Survival of the entire system depends upon contributions of many different individuals.	The reef must have different species to survive because of the food chain needed to exist.	Species diversity is important to maintaining vitality.	Science survives as a result of contributions from different races, cultures, religions, and genders.
A living system depends upon the success and well being of individuals in a community.	Yes, depend on each other, but live independently.	Death occurs when individuals contributing to the overall health of the system are lost or when overall species diversity decreases.	Breadth and depth in science occurs when multiple ideas and theories are put forth by a variety of individuals.
Systems do not exist in isolation from the environment and outside influences.	No, they do not. People and the weather can have influence on the reef, e.g., oil spills, etc.	Pollution, storms, global warming and silt deposits have significant impact on reef health and stability.	Things outside the direct realm of science, such as the Dark Ages, plagues, wars, money, and competition, cultural and religious beliefs can have a significant and long-lasting impact.
Communities are often viewed at the macroscopic level, but much is also occurring at the microscopic and basic levels of the system.	Microscopic level, although not visible, affects the reef community as a whole.	Some algae and bacteria have a symbiotic relationship with cnidarians building the coral; things dissolved in the water (water quality) can destroy the reef.	Famous scientists did not achieve greatness on their own. Scientists rely upon many different individuals including other scientists, laboratory workers, clerical help, and janitorial personnel.
Communities continue to grow and change.	Plants/animals die, regenerate.	Healthy reefs continue to grow as new calcium carbonate is added to the reef. Species diversity and population number may change over time and with the seasons.	Knowledge base is constantly growing. In 50 years, have gone from knowing that DNA was in a cell to understanding individual genes.
Under some circumstances the health and integrity of a community may be compromised and recovery may or may not occur.	Pollution, earthquakes, volcanoes, excess species population.	Predators may invade and destroy the species balance. Modulation may occur, but severe changes may cause system to die.	On rare occasions unethical conduct may occur. Scientific community responds and corrects the problem.

considered to be the most significant contribution or development to the medical sciences for their assigned time period. The time line activity concludes with each team reporting its collaborative findings to the class and submitting its individual findings for a participatory grade (Figure 3 – Rubric).

Assessment

To determine if the exercise had an impact, each student was asked to again respond to the question "What does diversity mean in the context of science?" Before writing a response, students were told that if their views had not changed they should indicate that in their answer. Although some of the students continued to hold onto their first response, some student viewpoints did change significantly. One student's initial response was "I think diversity in science means the different fields." His final response was "Diversity in science still means the same thing to me, but I also see a new point to diversity–diversity also means the different times, places, people, races, etc. that contributed to science." This particular response indicated to us that the activity can have an impact and that student perspectives on diversity can be broadened.

Some Final Thoughts

From the beginning of time mankind, by virtue of cognitive abilities, has contributed to the advancement of science and technology as evident from the discovery and preservation of ancient

Figure 2. Some examples of library subject headings.

African American Scientists
Chronology Historical
Medicine Developing countries History Encyclopedias
Science Developing countries History Encyclopedias
Science History Chronology Tables
Scientists Dictionaries
Technology Developing countries History Encyclopedias
Women Mathematicians' Biography
Women Physical Scientists Biography
Women Scientists
Women Scientists Biography Encyclopedias

Figure 3. Understanding Culture & Society.

HISTORY OF MEDICINE TIMELINE

Name ____________________

Time period ____________________

Score ____________________

Vital Statistics Exercise: Absent – 0 Satisfactory – 5 Excellent – 10

1. Name (if known)			
2. Gender			
3. Race			
4. Ethnicity			
5. Country of origin			
6. Occupation			
7. Contribution			
8. Date of contribution			
9. Source of Information			

artifacts. Although the first mechanical manipulation of the environment occurred over two million years ago when tools were made by African Hominids (Hellemans & Bunch, 1988, p. 5), science based upon observation, formal study, and experimentation did not occur until almost 600 BC during the time of the Ionian Greek philosophers (Hellemans & Bunch, 1988, p. 1). Since that time many cultures, ethnic groups, females, and males have contributed to the advancement of science (Hellemans & Bunch, 1988; Helaine, 1997; Ogilvie, 1986).

Drawing a parallel between interactions of scientists and reef organisms is a novel way to engage students in critical thinking and active conversation about cultural diversity within the context of science education, and the multiple interactions that occur within the global scientific community (Wheeler et al., 1999). This model also provides a mechanism to address the comment that "teachers must encourage the majority culture to recognize that the contributions of minority cultures are essential for the well-being of a democratic society" (Abdi, 1997).

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