SCIENCE EDUCATION & CIVIC ENGAGEMENT

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Introduction

Mission Statement

This journal explores constructive connections between science education and civic engagement. It focuses on using unsolved, complex civic issues as a framework to develop students' understanding of the role of scientific knowledge in personal and public decision making. Published articles include topical reviews, research studies on teaching and learning, and connections between science education and public policy. Since many pressing issues are not constrained by national borders, we encourage perspectives that are international or global in scope.

An Introduction from the Editors

We join W. David Burns, the publisher, in celebrating the launch of this first issue of Science Education and Civic Engagement (SECEIJ) and in welcoming readers to this new venue for thoughtful, productive scholarship about the linkage of learning in the STEM (science, technology, engineering, and mathematics) disciplines to engagement in civic questions and public life. As a new shared intellectual asset, SECEIJ adds strength to the emerging corpus of work that advances reform in undergraduate science education through a variety of channels, applications, and strategies.

Starting a new peer-reviewed scholarly journal is not a job informed by a user's manual. As co-editors, we have soared on blinding glimpses of the absolutely obvious and suffered through problems that we unintentionally (but very effectively) fashioned for ourselves. It is fortunate that none of our mistakes was fatal to the project – a happy consequence of having good advisors, patient authors, and a certain quality of resiliency that comes, perhaps, with academic backgrounds. We are solely accountable for our errors, including those that will become apparent to others before we recognize them ourselves. But we are elated that the months of planning and preparing have come to this: a first issue; and that a small store of other submissions promises that the first will not be the last. The growth of a strong friendship among us and our ever-conscientious, never-frustrated Managing Editor, Kyle Hutchison, is but one marvelous by-product of those efforts. Without Kyle there would be neither a first issue nor surviving editors.

SECEIJ is truly an international journal, with an international focus. Our editorial board brings the strength of scholars in various disciplines from several countries – in addition to the US, South Africa, Georgia, and Honduras. Members of the editorial board are listed separately herein; as editors, we take great pleasure in acknowledging their work and thanking them, on behalf of the authors as well as ourselves, for their mentorship, good humor, and service.

The first issue is exactly that, a beginning; we are grateful to the authors who have helped make it a strong one. Debra Meyer of the University of Johannesburg leads with a review article on the impact of HIV/AIDS on educational systems, learners, and educators in Africa. Two project reports document specific innovative programs – a joint program in environmental science for the Colleges of the Fenway (by Ellen E. Faszewski and Jack Duggan) and a project on science literacy for non-majors at Philadelphia University (by Anne Bower, George Buchanan, Jaclyn Dispensa, John Pierce, and Faye Ross). In the books, media, and exhibits section, Laurie Fathe (of George Mason University) reviews Learning to Think, by Janet Gail Donald, and Trace Jordan (of New York University) reports on Darwin, an exhibit at the American Museum of Natural History.

As this issue reaches you, we are turning our attention to review and discussion of other manuscripts and planning ways to make the Journal an important and strategic resource for scholars, scientists, and teachers, both in college and K-12 education. No reader will be surprised by our plea for submissions; the lifeblood of any journal is in the research, teaching, and practice of its contributors. The frequency with which SECEIJ appears will be determined by the flow rate, if you will, of scholarship in the pipeline.

We offer this work to the community of teachers and scholars concerned about science education and committed to civic engagement, and we invite your comments, suggestions, and submissions. We are grateful for your confidence.

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Review Articles

HIV/AIDS in Africa and its Impact on Education

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Abstract

By 2001, 20 years into the pandemic, approximately 25 million people had died of AIDS; more than 15 million of them were Africans.[1] In Africa, some of the highest rates of mortality due to HIV/AIDS are being seen among teachers and administrators at all levels of education. HIV/AIDS affects every sector of African society, but the education sector merits high priority for interventions because education itself can have mitigating effects on the spread of HIV. HIV/AIDS directly influences the supply of (high mortality rates among teachers) and demand for (decline in learner enrollment) education, increases education sector costs, and decreases the quality of education. Education plays an undeniable role in economic empowerment, poverty reduction, social development, and progress of a country. Sound interventions including adequate strategic planning, strong leadership, and properly targeted and managed foreign aid are some ways to positively respond to the challenges of HIV/AIDS in Africa.

Introduction

The primary goal of this paper is to explore how HIV/AIDS in Africa affects education in general and tertiary or higher education in particular. In addition, an attempt is made to provide perspectives and explanations on cultural issues, HIV/AIDS myths, rules governing international aid, the practices of drug companies, etc., to orient the reader as to the uniqueness of HIV/AIDS in Africa. Finally, the paper reviews new (especially for tertiary education) and previously recommended interventions.[2-4] .

According to the UNAIDS report of 2005, 40.3 million people are living with AIDS globally with 4.9 million people infected in the year of the report. These numbers, if looked at on a personal level, include children, parents, husbands, and wives; on a more practical level, they reflect people in key roles, like health-care workers, politicians, soldiers, and educators. Education is a key factor in promoting social and economical development of countries, alleviating poverty, and improving living standards of individuals. In this era of HIV/AIDS, a basic education has been proven to be effective in lowering infections,[5] just as education has also helped people understand how to care for those living with AIDS and to engage the numerous public policy and human relations issues that HIV/AIDS brings into sharp relief.

HIV/AIDS in Africa is synonymous with suffering and loss of life; the fact that this epidemic is reversing gains in social and economic development only serves to compound the tragedy. The list of consequences has become painfully familiar: dropping average life expectancy, reductions in rates of economic growth, governments struggling to deliver essential services, including health care, crime control, and national defense. The ministries of defense of several African countries have estimated 20-40% infection rates among African soldiers in 2001; in that same year, 75% of police deaths in Kenya were linked to AIDS.[6] Poverty, always a challenge in African nations, becomes even more difficult to resolve because of its close linkages with HIV/AIDS. How can we work towards the alleviation of poverty without serious consideration of HIV/AIDS, especially if the economically active are increasingly becoming infected with the virus and eventually dying of AIDS? The creation and dissemination of new knowledge – key to reducing the scope and impact of HIV/AIDS throughout Africa – may be stymied by governments that undermine scientists, question the scientific method, and stifle the establishment of a research culture -- the very research culture that could support and achieve the critical goal of developing an effective vaccine.[7,8]

An Overview of HIV/AIDS in Africa

It seems needless to say that because the dynamics of AIDS in Africa differ from those known in the developed world, a different approach for dealing with the epidemic is required. Different patterns of viral transmission, higher rates of infection, different opportunistic infections, and higher frequencies of sexually transmitted infections (STI) are seen in Africa.[7]

Africa is home to 13% of the world's population;[9] it is plagued by excessive poverty, extremely high levels of illiteracy, and now also the largest number of HIV infections worldwide. AIDS has surpassed malaria as the leading cause of death in Africa and kills more Africans than war.[10] The disease has also created more than 12 million "AIDS orphans,"[11] children who face an increased risk of malnutrition and reduced prospects for education, if they themselves do not have their lives cut short by the disease.[12]

Reference to statistics is unavoidable in any discussion on HIV/AIDS, if for no other reason than to highlight the continuous need for meaningful, way-forward discourse and strategizing on this devastating epidemic. Most statistics cited in this paper come from the UNAIDS/ WHO reports, which in the case of sub-Saharan Africa, rely on antenatal clinic survey data and will most likely be adjusted when other relevant information emerges and evidence-based observations are made.[1,11]

AIDS is the leading cause of death in sub-Saharan Africa.[1, 10] Barely 10% of the world's population comes from this region yet more than 60% of all people living with AIDS (25.8 million) reside there.[11] In 2005 3.2 million new infections occurred in the region and an estimated 2.4 million adults and children died there as a result of AIDS in that year. Of all adults infected globally, 46% are women, but in sub-Saharan Africa, this number reaches 57%. Sub-Saharan Africa is the only region of the world where more women are infected than men; young women (15-19 years) experience higher infection rates than men of the same age.[10] In much of sub-Saharan Africa knowledge about HIV transmission routes is still low and generally women are less well-informed than men.[11]

Eastern and Southern Africa are more severely affected than the Central, Western, and Northern regions of the continent.[11, 13] Southern Africa remains the epicenter of the global AIDS epidemic; there, the prevalence of HIV infection among pregnant women is still exceptionally high (above 30% -- and without preventive therapy, up to one third of infected women's babies will be infected via peri-natal transmission or breastfeeding, and most of these children will die by the age of 8).[13] East Africa continues to provide the most hopeful indications that serious AIDS epidemics can be reversed.[11] Public education efforts in Uganda have helped stabilize or decrease the spread of AIDS.[1,5,11]

The effect of AIDS on Education

Education has always been instrumental in increasing knowledge; the advancement of knowledge is a necessary, yet insufficient, ingredient in changing attitudes and behavior. Many consider education a key element to the development and alleviation of poverty on the African continent.[2,5] In Africa, before the advent of AIDS, education was laboring under the weight of substantial problems, especially low enrollment (predominantly among girls), human resource shortages, poorly trained teachers, and a lack of books and infrastructure.[14,15,3] AIDS has simply made these obstacles all the more challenging.

While HIV/AIDS presents challenges to every sector of African society, the education sector merits especially high priority for urgent interventions. Nine reasons for such urgency are explained below:

1. *The worth of a basic education is undeniable as a general principle*. Such education plays a critical role in HIV/AIDS prevention: a basic education ranks among the most effective and cost-effective means of preventing HIV according to a World Bank report,[5] which advocates for the vigorous pursuit of education for all. Schools and teachers can provide children with the knowledge, values, and skills with which to make healthy decisions, bring about healthy behavior, and give the desire, if not the opportunity, to achieve economic independence.

Schools also offer ready-made infrastructure and easy educational access to people in some of the high-risk groups (especially young people--learners and teachers--15 to 24 years of age). Educational systems can facilitate the design and implementation of effective prevention programs.

2. *Education is vital in reducing the special vulnerability of girls* who, because of social, cultural, economic, and physiological factors, are at higher risk of contracting HIV.[5] The education of girls can assist in slowing the epidemic by

contributing to female economic independence and improving the girls' consciousness of self worth. Education can also provide information on family planning, work outside the home, and other options and life choices. Education, in other words, can be liberating for girls.

3. The HIV epidemic is depriving some children of the benefits of education by interrupting access to it. Children who are caring for sick or dying parents may not gain access to education, or may be forced to drop out. Caring for a relative may require staying home to do chores, including "surrogate nursing." Equally, parents who are ill with AIDS may be unable to provide the emotional and "tutoring" support needed for their children's success at school. With children leaving school to care for sick or dying parents, the demand for education declines. When the young do not get an education, their economic prospects decline. Through chains of cause and effect like these, HIV/AIDS undermines a country's future.

4. AIDS is decreasing the number of children who are obtaining a basic education. Absenteeism and decreased demand for education by children who have become orphans is another by-product of the HIV/AIDS epidemic. When parents die, children, especially girls, are removed from school to attend to younger children and complete other chores at home. Grandparents inherit responsibility for the care of their grandchildren when the parents die and often cannot afford school fees. In this way, AIDS exacerbates the effect poverty has on education. The World Bank reported that one in four children end up leaving school before having learned to read or write and more than 113 million children are not in school in the poorest countries.[5] Research in South Africa showed that the number of pupils enrolling in the first year of primary school in 2001 in parts of KwaZulu-Natal Province was 20% lower than in 1998[16]. In the Central African Republic and Swaziland, school enrollment is reported to have fallen by 20-36% due to AIDS and orphanhood, with girls being most affected.[1,16] The US Bureau of Census suggests that 6 out of the 26 countries worst affected by AIDS will show an actual reduction in school-age population by 2015.[5] Free primary schooling in Malawi and South Africa has been lauded as a step in the right direction towards assisting young people, especially girls, with getting an education.[1] Yet these gains have been curtailed by AIDS.

5. HIV is limiting the supply of education. Africa is experiencing increased mortality rates among teachers and administrators at all levels of education. The World Bank estimates (in a Report launched at the 2002 AIDS Conference in Barcelona) that in countries with very high infection rates, AIDS is killing teachers faster than new ones can be trained.[12] To fulfill the demand for teachers, some education departments may cut costs in training, or may leave positions unfilled, or fill positions with teachers who are not optimally qualified. The deaths of staff also create ruptures in continuity that negatively effect educational outcomes. HIV/AIDS is thus negatively influencing both quality and quantity in the teacher population. In Zimbabwe, estimates show that 19% of male and 29% of female teachers are infected with HIV and approximately 17% of all teachers in Mozambique are believed to be HIV positive.[16] In Zambia, teacher deaths are equivalent to about half the total number of new teachers the country manages to train.[13] In the Ivory Coast, five teachers reportedly die from AIDS during each week of the school year. Illness or death of teachers is especially devastating in rural areas where schools depend heavily on one or two teachers. Swaziland will have to train 13,000 teachers over the next 7 years, just to keep services at their 1997 levels--this is 7,000 more than it would have to train if teachers were not dying from AIDS.[16]

6. Weakening the education sector also undermines the possibility of having that sector deliver necessary AIDS education: Education on HIV/AIDS is necessary not only to enhance prevention, but also to improve general health knowledge, and to combat the stigma and fear surrounding the disease. To the extent that AIDS is weakening the educational sector, *per se*, it is also limiting the opportunity that sector has to provide vital HIV education; in turn, creating a "vicious circle." Girls suffer the most, which is evidenced by their school dropout rates and non-attendance, coupled with their inaccurate or lack of knowledge about HIV.[11] In Uganda, an important tool in reducing HIV/AIDS prevalence was the use of information campaigns to educate people about the existence of HIV/AIDS and the means of prevention. A study in 15 villages in the Masaka District has shown that these campaigns have been most effective among individuals with more years of primary education.[2]

7. AIDS is increasing education sector costs: With the effects of loss of productivity and human capital, as well as increased dropout rates, education budgets must absorb even higher costs while not obtaining increases in productivity or improvement in outcomes. Teacher hiring and training costs needed to replace those who have died, as well as the payment of full salaries to teachers who are sick and absent, stress an already under-funded system.

8. AIDS is creating a special crisis in tertiary level education: Many tertiary institutions report[17,18] or predict severe HIV infection rates among students and staff. A loss of large numbers of educated individuals to AIDS severely reduces the economic and intellectual capacity of a country. Development and progress continuously necessitate the need for skilled labor, so called "human capital." Progress and advancement also require biotechnological competence and the ability to utilize the benefits of information technology. Losses in the development of these competencies, at the tertiary and graduate education level, add to the difficulties in the African tertiary education systems, systems that are already functioning under worsening socio-economic conditions. The losses coming from AIDS threaten to undermine whole systems of tertiary education, in teaching, research, and engagement with community and national projects of importance.

9. Strategies for dealing with HIV/AIDS in education. Reports commissioned by the World Bank[2,5] and UNESCO[3] provide promising input and useful way-forward suggestions for education sector decision makers. Suggestions involve the pursuit of education for all, strategic planning (predicting/projecting future education sector needs), school-based prevention programs, curriculum renewal, skills-based health education, peer education and focus on the youth, support for orphans and out-of-school youth, multimedia campaigns, partnerships across sectors (private, communities, NGOs) within a country and internationally, and sourcing and appropriately managing funding to ensure the success of the suggested approaches. It remains to be seen how many of these initiatives can become reality.

Putting AIDS in Africa in Perspective

A number of factors explain the extreme severity of the pandemic of HIV/AIDS in Africa.

Epidemiological explanations: AIDS in many African countries is generally caused by HIV-1 Subtype C, which may spread more easily through heterosexual contact (the main mode of transmission in Africa) than Subtype B, which is common in the United States and other developed countries. To the extent that this is true, the entire sexually active population is more vulnerable to infection in Africa than in continents and countries where Subtype B is dominant. The high prevalence of genital ulcer disease in regions where the HIV epidemic is severe is an important co-factor; genital ulcers caused by some bacterial (e.g., Haemophilus ducreyi) and viral (Herpes simplex virus type 2, HSV-2) sexually transmitted infections (STIs) are efficient portals of entry for HIV.

Cultural explanations: Cultural factors also play a role. Male circumcision, to pick just one example, is reportedly more common in West Africa than in eastern and southern Africa. Some scientists suggest that this fact helps to explain the comparatively lower rate of infection in this region.[19] Female circumcision, on the other hand, has been identified as a factor contributing to the transmission of HIV/AIDS. Examples of other cultural patterns that may influence the spread of HIV/AIDS include: rituals of blood exchange in certain initiation ceremonies of young men; sexually inexperienced girls being encouraged to marry at a young age and to marry older men; the custom of wife inheritance; the fact that periods of long illness in men is viewed as a curse or a spell for which some traditional healers may recommend sex with a virgin as a cure; and, the belief that a man's achievements can be measured by the number of sexual partners and children he has.

AIDS myths and beliefs: One of the worst myths AIDS educators on the continent struggle against is the belief among some men that sex with a virgin can cure the disease. The origin of this myth (and many others) is unknown, but it is easy to see how acting on this belief can contribute to the spread of HIV and the exploitation and infection of young women. The unfair belief that the causes of African AIDS mortality and high infection rates are simply based on sexual behavior belies the influence of migrant labor (a colonial invention) and real African cultural practices, such as wife inheritance. Some Africans believe that HIV was created by the developed world in a laboratory in order to minimize the number of poor (and black) people worldwide.

The cultural attachment of Africans to traditional healers and their *muti* is often misunderstood. *Muti* is the Zulu word for a concoction of many substances including but not limited to herbs, hair, bones, and other body parts of animals and/or people, prepared under the guidance of the ancestral spirits. Existing over-the-counter and prescription treatments for many diseases have their origin in plant materials. Thus, herbal muti may prove to be beneficial even to HIV infected people.[14]

These beliefs constitute what we might call a "civic epistemology of AIDS." To successfully launch education efforts one has to be aware of existing beliefs in order to be able to directly address them. Uganda, Thailand, and Cambodia have lowered HIV prevalence[1] by relying heavily on information, education, and communication. Similar achievements in Africa will depend on developing educational messages and campaigns that account for cultural beliefs.

Economic explanations: Poverty and HIV/AIDS are linked in many ways. Poverty forces men into migrant labor, where they spend several months away from their families and wives. While away, these men may engage in unprotected sex with prostitutes. For some women poverty leads to prostitution (obviously increasing their risk of infection) as a means of obtaining an income. Migrant laborers and long-distance taxi drivers literally transport the virus between rural and urban areas. Poverty is linked to poor nutrition that, in turn, results in weakened immune systems, leaving food-deprived people susceptible to opportunistic infections, etc. The costs of providing treatment for people with AIDS competes with other pressing needs and drains scarce resources allocated to education, agriculture and other sectors important to a country's gross national product.

The circumstances and situation of HIV/AIDS has prompted a serious consideration of the cancellation of African debt in favor of investment in the social and health sectors. That said, African governments that claim that the reason little is done to procure anti-retroviral pharmaceuticals for their people is because these drugs are too expensive need to explain why they choose instead to spend millions of dollars on military equipment and armed conflict. According to a paper presented at the 45th Session of the Commission on the Status of Women, one eighth of the military budget in most African countries would have been enough to supply free antiretroviral drugs to every one living with HIV/AIDS in those countries in 2001.[20]

Social explanations especially connected to the status of women: Another issue warranting considerable attention in understanding the epidemic in Africa is how the status of women influences the spread of HIV. African women, because of their social, cultural and sexual subordination, are disproportionately affected by the epidemic and require special consideration, especially when planning interventions. Even with the existence of the Convention on the Elimination of all forms of Discrimination against Women (CEDAW, adopted by the UN in 1979), the legal systems and cultural norms in most countries support and exacerbate gender inequality in a variety of ways. These include: giving men control over productive resources such as land, making wives subordinate to their husbands (through marriage laws), and making men principal beneficiaries of family property (through inheritance customs).

HIV infects people regardless of sex, race or social status, yet more women are infected than men in Africa and there is a higher prevalence in younger women.[21,22] Young women in their teens and twenties have higher infection rates than females in other age groups. The fact of higher infection rates in women vs. men in Africa is attributed to a claim that women are more promiscuous. A more factual explanation is that women marry young (mostly while still in their teens) to older, more sexually experienced men who may expose their new wives to HIV/AIDS and other STI's. Abstinence for these child brides is not an option, nor is trying to negotiate or insist upon condom use. Both gestures could expose them to violence or rejection. The disparity in the numbers of infected men and women in Africa shows that social inequalities facilitate the spread of the virus. Education is a very important part of this equation. The high illiteracy rates among women means that access to and understanding of written and validated HIV/AIDS information will be limited.

To put it bluntly, there is a relationship between women's lack of power and their risk of HIV. Beyond the cultural practices and beliefs mentioned above, women and girls are at great risk of being raped and/or physically abused. These traumatic experiences represent tragedies in and of themselves. They also carry with them sequelae, such as lowered self-esteem and a decreased sense of self worth, that only further decrease the likelihood of the woman being in any way "in control" of her own person in negotiations about sexual activity. Hamblin and Reid[21] discuss why unique interventions based on the special circumstances women face are needed. Reid and Bailey[22] suggest the serious consideration of possible special anatomical, immunological, and biological susceptibilities of young women to HIV infection.

African Leaders and AIDS: A lot of criticism of the response of the African continent to HIV/AIDS is aimed at her leaders. Many believe that the spread of AIDS in Africa could have been slowed down if African leaders had been more engaged and outspoken earlier in the struggle against the disease. The United Nations convened a major conference on AIDS in Africa in Lusaka (Zambian capital) in 1999, but none of the fifteen invited African heads of state attended. Former President Daniel Arap Moi of Kenya did not endorse the use of condoms as a preventive until December 1999.[23] South Africa's President, Thabo Mbeki, questioned the effectiveness of AIDS medications used in preventing mother-to-child transmission and gave a platform to AIDS dissidents (scientists who maintain that HIV is not the cause of AIDS). On a positive note, though, President Yoweri Museveni of Uganda has won recognition for leading a successful campaign against AIDS in his country.

African leaders routinely emphasize negotiating reduced drug prices as a principal requirement for their success in dealing with HIV, while others focus on calls for debt cancellation as their major concern. (This is a possible example where one agenda—debt cancellation, albeit a plausible and desirable strategy for freeing up funds for other things like fighting AIDS—takes precedence over a more narrowly focused public health agenda.) But, for the most part, even today, Africa's leaders have yet to prove themselves able to provide consistently effective leadership as far as AIDS is concerned.

"*International aid*": Some western aid agencies apply rules that work in San Francisco, Soho, and Sydney directly to the African context. According to the article, "Africa is dying of this western madness," some aid agencies require an individual one-hour counseling sessions prior to HIV-testing. In Botswana, where 1 in 3 people are believed to be infected with HIV, this alone would require 300,000 man-hours.[24] Another western aid agency rule suggests that for patients to get anti-retroviral drugs they must see a doctor four times a year for compliance assessment, blood tests, and more counseling. These kinds of requirements, though probably well-intentioned, are unrealistic in the African context because of insufficient trained manpower, distances people live from hospitals/clinics, costs of blood tests etc. Funding rules have to be modified to suit the realities faced by HIV-infected people in Africa.

Donor organizations, institutions and governments have repeatedly used the Africa-AIDS problem as a platform for promoting their own agendas, instead of providing what a particular country needs. Citizens of a number of African countries are still being used for the testing of AIDS drugs. But few will ever benefit from the results of the research, because treatment is only offered until the efficacy of the drug is demonstrated. In the author's view, US drug companies, and even the US government (CDC and NIH), funded unethical research when they authorized the use of placebos in control groups to confirm that AZT lowered mother to child transmission of HIV in Uganda.[25]. The US watchdog organization, Public Citizen, identified 15 unethical US government-funded HIV studies in developing countries in 1997. Multinational corporations have also vehemently opposed and resisted changes in patent laws, laws that presently allow for monopolies in pricing and production of anti-retroviral drugs. Up to now, the companies have been reluctant to make concessions for the kind of HIV/AIDS public health emergencies experienced in Africa. US drug companies only lowered HIV drug prices after 22 million deaths;[1] for many, that was too little too late. For most Africans with HIV/AIDS, extreme poverty means they cannot afford even these "cheaper prices."

Teaching at Tertiary Institutions in Africa in the Era of AIDS

One of the issues this paper seeks to address is how tertiary institutions (what in the US is called "higher education") can address the complex and enormous challenge of giving curricular attention to HIV. To understand the challenge, it is useful to give some background on the higher education systems on the African continent, with special reference to the pedagogical traditions.

Teaching styles: Though notable exceptions exist, most faculty members maintain very traditional teaching styles, often those in vogue in the countries that held colonial power over a given African state. Traditional or formal teaching means one speaker addresses several learners and the interruption of the lecturer for the purpose of asking questions is not encouraged. These teaching styles promote passive absorption of information and are still widely accepted and widely employed. This means that there usually is very little promotion of active intellectual engagement between student and professor.

Curricular structure: Most African tertiary institutions lack what in the US is called a general education component -- a set of common courses or learning opportunities that can support broad educational goals. This lack of common courses for undergraduate students makes it difficult, for example, to introduce a general HIV-course that would be compulsory for everyone. Typically, students register for a qualification in one faculty and are not allowed to take courses (for credit) in other faculties. Science students are only allowed to attend science courses. An art student would not be allowed to attend science courses. Undergraduate science education at tertiary level overemphasizes "theory." This reality does not reflect thoughtful pedagogical practice; rather, it derives from both tradition and scarcity. Where a practical, "hands-on" laboratory or field experience or demonstration would be pedagogically recommended, oftentimes such learning is not possible because of large class sizes and absence of personnel and equipment.

It is not surprising that against this backdrop of teaching and curricular traditions, the study of HIV has not become a feature in the experience of many African college students. For this to happen, some other critical changes need to happen as well. It would be necessary to change traditional teaching styles and educational culture, because innovative ways to address issues that have been usually viewed as personal, private and highly confidential must be discovered to educate the emerging elites and to halt the progress of HIV/AIDS.

Teaching on HIV/AIDS also requires aspects of continued education (now formally only required for health care workers) for other disciplines, as well. HIV is a changing phenomenon. Up-to-date factual information and knowledge is needed to enable graduates to function in their various roles in the economy and, as citizens, to be capable of making sound judgments on policies and programs. This continuing education will also be needed to refute misinformation, and deal with myths and folklore surrounding the disease.

The advent of outcomes based education in some African countries promotes the revision of course content and teaching styles while also allowing for the incorporation of other learning tools. Methods of teaching and learning that are encouraged include group discussions, role play and simulation, visual aids, learning aids, learning through games and plays, and most recently, story telling, which can be easily adopted because it is already a traditional aspect of African culture. Most of these approaches, however, are not simply incorporated into the teaching of science. Outcomes-based education tries to capture international trends and tendencies in higher education with specific emphasis placed on relevant, market-related, and applicable training.

Universities now face new conditions that require more systemic reform. These include: the digital revolution, which allows information to be stored, manipulated and transferred increasingly more cheaply and ubiquitously, the changing "image" of students who are now viewed as clients of the university and thus can "demand" quality, service, and other changes, and also the influence of more foreign universities operating in some African countries bring with them "new ways" of doing things. Another factor leading to institutional change is the intense competition that exists among universities to recruit top students, especially on post- graduate level.

Innovative teaching models: Science Education for New Civic Engagements and Responsibilities (SENCER): Since the advent of outcomes-based education requires revision of past teaching styles, course content and learning resources, it allows room to incorporate innovative new teaching strategies like those developed through SENCER. The SENCER concept is to "teach science through the lens or doorway of a compelling social issue,"[17] and this approach requires students to engage in serious scientific reasoning, inquiry, observation, and measurement, while connecting scientific knowledge to public decision-making, policy development, and effective citizenship. HIV/AIDS is a profoundly critical social and scientific issue in Africa. It demands the attention and energies of the whole education sector. SENCER shows how studying AIDS also allows room for improving science education.

Even without outcomes-based education, however, SENCER approaches can be easily incorporated in Africa because the ideals of civic engagement, active pedagogies and service-based learning, along with goals for improved learning, better information retention by students, and improved science learning are essentially universal. Several East African universities have successfully incorporated SENCER concepts into existing and new courses.[14,17] The general impetus for reform, plus the urgency of dealing with HIV/AIDS and the need for curricular change to support the inclusion of the study of HIV/AIDS make this a most auspicious time to incorporate the SENCER ideals into tertiary curricula.

Faculty sensitivity: Beyond changing teaching styles and developing new curricular frameworks, the incorporation of HIV issues within courses will require increased faculty sensitivity. A change in attitude becomes a very important requirement for faculty teaching in an environment where the prevalence of HIV is as high as it is in Africa. Sensitivity towards the conditions under which the student has to function is essential. This includes the need for lecturers to consider the possibility that students, even if they are not infected themselves, are very likely to be affected by AIDS. They may be either living with and/or caring for an infected partner, parent or sibling. Faculty who want to help will find themselves paying attention to patterns of absenteeism in order to recognize the need for intervention, especially since issues of stigma may keep students from disclosing their conditions and asking for help, just as issues of confidentiality demand that suspicions of infection be handled with special care. African universities are slowly starting to put structures in place that assist staff and students in dealing with infection of either themselves or family members. Introducing HIV in the curriculum will mean that it is even more likely that students will come to rely on their professors for help. Thus, what I have called "increased sensitivity" means that faculty will need to be prepared to offer the help that is needed.

Issues of institutional leadership, government, and institutional autonomy: In many African countries, the autonomy of institutions and scientists is undermined by government.[15] Some institutions are directly accountable to government-appointed leadership, such as deans and vice chancellors, but also sometimes even department heads. In fact, scientists have on occasion been removed from office after criticizing governments or their leadership.[7,15] Again, the World Bank cites the need for improved governance as one of the five critical needs for higher education in emerging economies (improved science education and general education are also mentioned). Governments in Africa (as suggested by the task force on higher education and society)[15] need to develop new ways of achieving necessary accountability, while preserving some autonomy and academic freedom.

The Response of African Higher Education to HIV/AIDS

The response of higher education to HIV/AIDS in Africa has been discussed thoroughly by several authors[26,27] who mostly concluded that interventions were infrequent and disorganized, with few institutions having policies and frameworks concerning AIDS currently in place. These conclusions, published in 2001, did not consider education, counseling, and health care activities in which individual faculty members and departments were involved. Rather, the institutional, "group" response was primarily reviewed. But within a year or so, most, if not all institutions had policies, strategic plans and entire committees or departments dedicated specifically to HIV/AIDS.

Eight East African universities at an HIV/AIDS and Tertiary Education Workshop[17] held in Kenya in 2001 reported involvement in the following types of activities in response to the HIV/AIDS crisis: awareness raising and prevention, care and treatment, and medical research. These institutions also established AIDS committees or units that organize seminars and workshops for HIV awareness programs, provide educational materials, counseling, and distribute condoms. Some institutions also offer voluntary HIV-antibody testing and medical advice. In addition to the efforts of these AIDS-specific committees, most universities also reported HIV-related educational programs in other departments (e.g. centers for women's studies and gender issues, campus health departments etc.). Curriculum reform is also receiving increased attention, the focus being to incorporate HIV/AIDS in undergraduate coursework.

One similarity between US and African college students is that university first year students bring with them the complex legacy of HIV education efforts, which range from "abstinence only" messages given in some high schools and churches to informal knowledge transmitted by peers and television.[28] African first year university students will be faced with myths and HIV folklore alongside mixed messages on safer sex practices from governments and authorities. They will also experience difficulty in understanding the role of their cultural beliefs and practices in all this. For this reason some southern African institutions have conducted surveys on perceptions and prevalence (sometimes involving voluntary testing) of HIV/ AIDS on different campuses, to further encourage and design interventions.[29,18] These and other related studies have led to the design of more structured and specific interventions, the range and scale of which improves yearly. Many institutions are now establishing campus health services where before there were none; they are launching increased and continuous intervention programs where before there were isolated programs, events, and guest speakers. The involvement of students as peer counselors is also becoming more prevalent.

Conclusion

After more than two decades of AIDS, the pandemic in Africa is still raging. Sustained social/ national mobilization involving cross-sections of society with governments spearheading the process is imperative. Effective and comprehensive HIV/AIDS prevention, care and support strategies based on a multi-sectoral approach must continually be revised, updated and applied to stem the tide.

HIV/AIDS is an enormous and enormously complex issue, as is education. This paper provided an overview of both issues and analyzed what is happening at the important intersection between the two. Education is, at present, yet another tragic victim of the AIDS pandemic, but is also key in overcoming HIV. Indeed, it is hard to overestimate the damage that HIV is doing. But, there is room for encouragement; improving science education in tertiary institutions, and linking learning about HIV to civic engagement, may help African nations develop a cadre of young people who are prepared with knowledge and commitment.

List of Abbreviations

AIDS	Acquired immune deficiency syndrome
CDC	Centers for Disease Control and Prevention (USA)
CEDAW	Convention of the Elimination of all forms of discrimination against women
HAART	Highly active antiretroviral therapy
HIV	Human immunodeficiency virus
HSV-2	Herpes Simplex virus type 2
NGO	Nongovernmental organization
NIH	National Institute of Health (USA)
MRC	Medical Research Council (South Africa, abbreviation used in reference list)
RAU	Rand Afrikaans University (abbreviation used in reference list)
SENCER	Science Education for New Civic Engagements & Responsibilities
STI	Sexually transmitted infection
UN	United Nations
UNAIDS	United Nations Programme on HIV/AIDS
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations Children's Fund
WHO	World Health Organization

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Project Reports

Environmental Forum: The Cornerstone of a Joint Program in Environmental Science for the Colleges of the Fenway

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Abstract

The Colleges of the Fenway (Boston, MA) have developed a new joint program in Environmental Science. This program consists of three major components: a two-year core curriculum built on a strong foundation in the sciences, a COOP/ internship designed to provide experience and a greater understanding of how environmental solutions are created in real-world settings, and an introductory course titled, *Environmental Forum*. With the help of the Science Education for New Civic Engagements and Responsibilities (SENCER) dissemination project, this cornerstone course was created for the new program to provide a common identity for all environmental science students at the COF institutions. More than an introductory course in environmental topics, *Environmental Forum* brings together students, faculty and practicing professionals to discuss current issues, career planning, and civic engagement as well as to participate in service learning activities throughout the COF and greater Boston communities.

Introduction

In April 2003 a group of faculty, the Environmental Science Program Committee (ESP committee), representing five of the institutions in the Colleges of the Fenway (COF) consortium, began an initiative to develop a new COF Bachelor of Science Degree in Environmental Science. The mission of this new program is to utilize the strengths of the COF institutions and help students achieve a broad based knowledge of environmental science that can be applied in multiple fields. The program includes a two-year core environmental science curriculum taught at each participating COF institution, followed by a choice of several two-year specialty tracks; the tracks take advantage of the resources and faculty expertise of the participating institutions and currently include Pre-Law and Policy, Health and Safety, and Science and Technology. Formed in the spring of 1996, the COF is a collaborative effort of six neighboring Boston colleges in the Fenway area. The purpose of the consortium is to add value to student academic and social life that seeks innovative ways to provide new services while containing costs. Collectively, the Colleges represent 8,500 undergraduate students, comprising 12% of the total Boston student population.

Core Curriculum Development

According to data collected by Romero and Jones (2003)[1], there are currently 1060 schools that offer bachelor degrees in environmental science. Due to this large number of choices, we wanted to create a program that could offer students a unique learning experience. With this in mind, the program core curriculum was developed using input from three sources: 1) the COF ESP Committee, 2) the ESP Advisory Council (ESPAC) consisting of members from various environmental science organizations, agencies, businesses, and academia, and 3) the Council of Environmental Deans and Directors (CEDD). According to a report by the Business-Higher Education Forum[2], there is a widening skills-gap between what is provided in academia versus what is actually required in the workplace. By soliciting advice from these various sources, we believed that we would be able to offer a major that would consist of relevant content and experiences that would provide the knowledge and skills required upon graduation.

For the program to be successful, three components were developed: 1) a strong foundation in the sciences, 2) a COOP / internship experience, and 3) a course that would provide a common identity for *all* ESP students in *all* COF schools. Our idea for this third component of the core emerged as a direct need to bring together ES students from all the COF institutions. We designed this course, *Environmental Forum*, with several important characteristics in mind. For example, weekly meetings would foster interaction among ES students and faculty from all institutions to interact. *Environmental Forum* would also provide opportunities for students to learn about current public environmental issues and network with professionals from local organizations and businesses (Figure 1). For students to be effective leaders and citizens in their communities, it is imperative that they are able to make connections between their academic learning, the surrounding communities, and important public issues[3]. In addition, this course would provide opportunities for class discussions, field trips, and service-learning projects.

***Environmental Forum* and the SENCER community**

To develop this cornerstone course, we wanted to seek input from public and private environmental and educational organizations. It was with this in mind that our group was introduced to the Science Education for New Civic Engagements and Responsibilities (SENCER) community. SENCER is affiliated with Harrisburg University of Science and Technology in the National Center for Science and Civic Engagement. SENCER is a national dissemination project that offers various summer institutes, resources, assessment tools, and curricula to aid in science education (http://www.sencer.net). The vision of our program mirrors the SENCER ideals in several ways including:

1) strengthening learning in STEM fields
2) teaching scientific content using public issues
3) utilizing innovative teaching methods
4) connecting academic learning to the professions
5) increasing civic engagement

So, with these common goals in mind, and participation in three Summer Institutes (2003-2005), the *Environmental Forum* course was developed by Doug Crandall (Emmanuel College), Ellen Faszewski (Wheelock College), Rich Gurney and Tom Montagno (Simmons College). We created a course to provide a forum for multi-disciplinary assessment of current environmental topics (Figures 2, 3). These issues are addressed on a scientific basis as well as from socioeconomic and political aspects. The use of current societal issues in the classroom (as mirrored in SENCER's mission), has obtained success in environmental science courses, as exemplified in the Environmental Science Activities for the 21st Century Project funded by NSF (http://esa21.kennesaw.edu).

This course also includes a service-learning component that encourages student and faculty interaction with local, regional, and national environmental advocates. As described by the Commission on National and Community Service, service learning is a method that connects meaningful community service and academic learning, providing students with opportunities to use their newly acquired skills and knowledge[4]. The benefits of incorporating service learning into higher education are numerous, including: higher academic performance, increased civic responsibility and leadership abilities, and an increased awareness of the world[5].

Assessment

Jack Duggan (Wentworth Institute of Technology) coordinated the first offering of *Environmental Forum* in the spring of 2005. As the joint Environmental Science Program is new to COF community, most of the students enrolled in the course were non-environmental majors. To assess the course, a standardized questionnaire (used for all courses) and a course-specific questionnaire were used. Students uniformly rated the course with high marks for level of difficulty, organization, and relevance. In response to course-specific questions, the majority of the students experienced a greater appreciation for the following: multi-disciplined teams, respect for differing views, service learning, and environmental advocacy. The Service Learning component of the course also provided another means of assessment. Students were involved in developing promotional material of parks that were within walking distance of the COF campuses for a local urban parks program, Urban Wilds (Figure 4). During this experience, students "discovered" aspects of nature in these urban settings of value to both the neighborhoods and environmentalists.

> *"Another very fascinating subject brought to my attention at this park was the fact of how wide of a use it had. One can see the specific edges of where nature seems to be held back and a more manicured section begins. This part of the park is for recreational use and it is tamed to only contain grass and a small selection of decorative trees. If entered from two different sides one would never be aware of the fact that it is the same park or that it even shares the same vicinity. In the recreational part one can see more of an urban setting for the natural species of plants while in the less manicured part one can see the interaction spoken of earlier: the interaction of*

the invasive species and the natural species" (Reflections from an *Environmental Forum* student on the service learning project).

Due to this experience, students gained a heightened awareness of their community, an urban setting consisting of limited open spaces of various qualities. This combination of service learning and environmental issues provides students with valuable opportunities connecting them to the world around them[6]. Duggan also noted that student engagement in the course exceeded expectations. This was due in part to the nature of topics covered, which included: arsenic poisoning in Bangladesh; environmental education; green chemistry; and community activism. However, a greater cause for student engagement appears to be due to the make up of the students themselves. Over 60% of the students enrolled in the course were not born in the US and shared very different views on environmental policies. In addition, students came from environmental, architecture and design, natural and physical sciences, education and pre-law programs. This diversity fueled lively discussions of identifying issues and evaluating solution strategies. This in-class participation had a great impact on student learning and contributed to the success of this course. This year's assessment will also include the SENCER-SALG (Student Assessment of Learning Gains), which is a validated pre-and post-course on-line assessment tool that may be customized by faculty who are using it.

COF *Environmental Forum* students have met scientists, authors, world travelers and neighborhood groups. Overall, this course has helped students gain broader views on problems and solutions to environmental problems facing their world. For more information about the course and COF's Joint Program, go to http://www.colleges-fenway.org/consortium.htm or contact the Program Director, Jack Duggan (dugganj@wit.edu).

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Figure 1. ***Members of ESPAC talk with Forum students about current environmental topics.***

Figure 2. ***Jack Duggan, COF ES Program Director, welcomes Beth Daly, Boston Globe columnist.***

Figure 3. ***Beth Daly, Boston Globe columnist, speaks about covering current issues such as Cape Wind, America's first off-shore wind farm in Nantucket Sound.***

Figure 4. ***COF Environmental Forum students taking a walk on the (urban) wild-side at Massachusetts Audubon's Boston Nature Center as part of their service-learning project.***

Fostering Science Literacy: Non-science Majors Discover the Science behind National Public Health Issues

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Abstract

Inquiry-based education addresses the national challenge of building scientific skills needed in a democracy. College non-science majors analyzed data on national policy and personal lifestyle choices centered on pressing public health issues (obesity, smoking, drinking water, skin cancer, pesticides in food and genetically modified organisms). Following EPA protocols, students measured lead in client households with children and developed reduction recommendations. Pre- and post-tests showed significant increases in confidence in scientific skills, civic involvement and overall attitude towards science. Students used the course experiences to evaluate risk and explore health improvements in their daily lives.

Introduction

National Science Education Standards[1] clearly state that scientific literacy is critical for informed decision-making in a democracy. Yet as science educators can attest, the utility of science is not always apparent to students, especially non-science majors. Caprio[2] points out that the content of what is often taught to non-majors emphasizes the history of scientific discovery by famous scientists and does not explore current unsolved topics that scientists are grappling with in today's social and cultural context. Although students may gain an appreciation for the history of science, they see little relevance to their current lives or future careers. Science courses become a myriad of unimportant and disjointed facts. In actual fact, scientific information and modes of inquiry permeate our everyday lives and are used regularly by the public without their even being aware of it.[3]

Discovery or inquiry-based educational approaches have been used successfully to increase students' analytical skills, interest and understanding of how scientists work.[4,5,6,7] Pratte et al.[8] had students measure, analyze and interpret their own lifestyle choices on environmental issues such as home energy use in relation to public policy. Using this approach resulted in increases in scientific content knowledge, analytical and interpretive skills, and greater awareness of the relevance of science to students' lives and society. Development of this type of curriculum is time-consuming, technologically-challenging, labor intensive and requires a team approach that includes additional staff with pedagogical expertise from education, technology and scientific spheres.[4]

Recognizing the problem of engaging non-science majors with material that they will actually use in their lives, a team of faculty and students developed an interdisciplinary inquiry-based course, *Exploring Science*, funded by a grant from the National Science Foundation. The purpose of *Exploring Science* was to increase non-science majors' interest, civic involvement, and confidence in applying scientific modes of inquiry in evaluating risk and lifestyle choices for the national public health issues of obesity, smoking, drinking water quality, skin cancer, pesticides in food, genetically modified organisms, and childhood lead poisoning.

We combined a metacognitive model of science education from the National Research Council[9] in which: "students develop an understanding of the subject matter, learn when, where and why to use the information and learn to recognize meaningful patterns of information" (p. 50) with a focus on the civic implications of unsolved national public health issues. Previous research studies indicated that students who grappled with the social and political implications of unsolved scientific issues such as HIV/AIDS, global warming, brownfields, or diabetes had increased confidence in understanding scientific issues, witnessed a gain in scientific skills, changed beliefs about the relevancy of science, and retained more information after course completion.[10]

Methods

Participants

Philadelphia University offers 40 different degree programs and has an undergraduate student body of 2,184. Eighty-eight percent of Philadelphia University's undergraduate students major in Architecture, Design or Business. As part of the general education requirements for a Bachelors degree, students must complete two science courses. *Environmental Science* is the first required course and is typically completed in the freshman year. Students have a choice of Biology, Chemistry, Physics or the newly-developed *Exploring Science* as their second science course, which they typically take as sophomores.

Students voluntarily enrolled in three separate sections of *Exploring Science* in Spring and Fall 2005. Full-time faculty taught the first group of ten students and adjunct faculty taught the other two courses with twelve and thirteen students, respectively. Each course had one or two student mentors who were upper-level science students and had been trained in inquiry-based teaching pedagogy. Students enrolled in the course were freshman to seniors with 69% in their sophomore year in college; 92% were Caucasian, 80% were female and 69% had a cumulative GPA of 3.0 or higher. Most were majoring in fashion design, fashion merchandising, graphic design, psychology, finance, marketing or computer information systems.

The educational research plan for assessing the course was approved by the Human Subjects Committee of Philadelphia University prior to initiation of data collection and reviewed annually. All students were informed of the study: their participation was both voluntary and anonymous for all instruments used.

Course Description

Exploring Science consisted of five contact hours per week divided into blocks of two and three hours so that students would have sufficient time to engage in discovery-based activities. The course content included six week-long, hands-on analytical modules centered on public health issues (obesity, smoking, drinking water quality, skin cancer, pesticides in food and genetically modified organisms). The remaining eight weeks of the semester focused entirely on a discovery-based community health project to provide students with a civic engagement experience in a scientific issue. Students used interview, field and laboratory techniques based on Environmental Protection Agency protocols to sample dust, paint and soil in volunteer clients' homes. Students developed a sampling plan and recorded sample locations on a floor plan and exterior map, kept careful track of chain of custody, and then analyzed lead levels in the laboratory using an Atomic Absorption Spectrophotometer, which were compared to known lead concentrations. They compared the results to EPA legal limits as well as current medical studies and created a final Powerpoint presentation and report for all clients which included a thorough analysis of the lead levels in the home, recommendations for reduction and remediation, and resources available to the client. The EPA's regional environmental justice officer provided an overview of the issue of childhood lead poisoning to all classes and attended the final presentation of results, as did the clients and other University faculty, staff and students.

Each public health module centered around a hands-on laboratory experiment in which students hypothesized, created treatments, collected, analyzed and interpreted results and discussed policy implications. Interspersed throughout the module was a short overview of the history of the national health issue, a video of community and government agencies working on the issue, a wide array of scientific references collected and critiqued by students in terms of their scientific credibility, validity and reliability, links to current environmental and public health policies and regulations, a series of hands-on analytical exercises comparing data from a range of scientific studies, a lifestyle assessment in which students measured their own behavior, and large and small group discussions.

In addition, students worked outside of class either individually or in small groups by participating in a web-based discussion board on the current public health issue in which they analyzed scientific data from the literature to support or refute their viewpoint. Each student wrote a summary reflection paper that reviewed the results of all activities in the module in relation to their own lifestyle choices. Each student was required to share his or her findings with five family members or friends and then bring the results of that discussion back to the class along with any comments, questions and suggestions.

Throughout the course, students not only reflected on what they were learning, but also how they were learning. Students used the VARK learning style assessment to see what combination of visual, aural, read/write, or kinesthetic learning preferences they had and then examined different study and learning strategies.[11] All course materials including tests were designed to accommodate all four learning styles.

Sample Module: Is Obesity a National Health Issue?

We will use an overview of the obesity module to illustrate how we integrated these pedagogical approaches. Students watched the 2003 documentary, *Super Size Me,* in which Morgan Spurlock, the film's producer, undergoes a 30-day McDonalds-only diet while a team of doctors assess his health before, during and after. The film was paused at selected points so that students could either record Morgan's health data or discuss issues such as whether there is an obesity crisis in the United States, what is the impact, who is responsible, and what should be done based on statistics and interviews shown in the film.

Immediately following the film and discussion, students worked individually and in small groups over the next week to measure their daily lifestyle choices in reference to the obesity debate. They used nutrition fact sheets from a wide array of fast food restaurants to analyze what percent of the USDA dietary recommendations for calories, fat, sodium, carbohydrate, cholesterol and fiber were consumed in a single meal of their choice. They then used an analytical balance to weigh the amount of fat and sodium that corresponded to the food items in the main course as well as the amount of sugar in any non-sugar-free beverage. All samples were labeled and assembled together so students could visually compare the quantities of fat, sodium and sugar found in the fast food meals they eat. Students then discussed which were the best nutritional choices for children and adults, what the implications of these choices were, and what alternatives were available. This discussion occurs in the context that consumption of fast food has increased five-fold between the 1970's and 1990's with the result being that today 30% of children in the United States consume fast food.[12,13] Students calculated Morgan Spurlock's Body Mass Index (BMI) from before and after 30 days of fast food consumption and then measured and interpreted their own BMI using both the height and weight method[14] and a Body Fat Analyzer. They recorded their daily activity levels and measured and analyzed their total number of steps per day for a week using a pedometer. They then compared their results to a research study that indicated college students took fewer daily steps than children ages 6-12.[15] They measured and graphed the classes' resting, target and maximum heart rates in response to a step test.[16] They compared their lifestyle choice data to that from two research studies of dietary and exercise patterns of college students which analyzed the national trend that freshmen gain weight.[17,18]

Students participated in a week-long web-based discussion in which each class chose a different topic. One class compared and contrasted scientific research findings on the health impacts and long term effectiveness of popular diets (Atkins, South Beach, DASH and Weight Watchers); whereas another class chose to go to a restaurant of their choice to try to find and use a nutrition fact sheet to order a healthy meal (within USDA Dietary Guidelines). Students shared information throughout the module with five family members or friends and reported back the results of these discussions via the web-based discussion board. Finally, students reflected on their overall experience in the module by writing a short summary of five lifestyle choices they would likely change or had already changed as a result of having measured and examined the various facets of obesity as a national health issue and what scientific data this change was based upon.

Assessment Tools

Change in non-science majors' interest, civic involvement and confidence in using scientific modes of inquiry in evaluating risk and lifestyle choices for public health issues were assessed using both quantitative and qualitative methods. Quantitative assessment included comparison of post-only University evaluations of this course versus all other science courses offered in a given semester as well as use of a national pre- and post-test survey. Qualitative assessment included student reflections on the course during, at the end of the semester and one semester after participation.

Post-Only University Course Evaluations. University-wide standard course evaluations with 12 questions on instructor knowledge, availability, course materials, assignments, and overall effectiveness for the three course sections were compared to each other and to the overall ratings for all science courses offered at the University for the given semester.

Pre- & Post-Test Student Assessment of Learning Gains (SALG). Changes in students' confidence in scientific modes of inquiry (questioning, analyzing, evaluating, communicating), interest, involvement, and attitude towards using science in their everyday lives was assessed before and after the course using a national web-based pre- and post-test survey, the Student Assessment of Learning Gains (SALG). This instrument is currently being used by Science Education for New Civic Engagements (SENCER) in assessing science education impacts nationally[19] and is available on-line (http://www.wcer.wisc.edu/salgains/fac/). Students reported changes in their confidence in using scientific modes of inquiry (17 questions), interest (9 questions) and involvement in scientific issues (11 questions) by rating each question on a five point Likert scale ranging from not at all confident (1) to extremely confident (5). All students voluntarily took the web-based SALG at the beginning and the end of the course. Pre and post means for each question were compared using paired student t-tests for all students enrolled in Exploring Science. Questions were then grouped into four variables to compare overall reported changes in learning and to compare any differences in learning based on course delivery:

Confidence in Critical Thinking. Students ranked how confident they were in discussing, reading, analyzing, evaluating, communicating, questioning or using scientific ideas.

Interest. Students indicated how interested they were in discussing, reading, teaching or pursuing additional science courses or a career in science.

Involvement. Students reported how often they discussed, read, volunteered, contacted a public official, voted, debated or attended a community meeting on a scientific issue. On the pre-test involvement was asked as: "In the past year how often have you engaged in the above activities"? The choices ranged from never (1) to more than three times in a year (5). For the post-test, involvement was asked as: "After finishing this class, I am more likely to engage in the above activities." Choices ranged from not more likely (1) to extremely more likely (5).

Confidence in Critical Thinking, Interest and Involvement were combined into a single score, **Attitude Towards Science,** and we analyzed paired student t-tests to assess differences.

Results

Table 1 highlights student reflections on how they applied course content and the three main learning objectives in their lives. In University course evaluations, 100% of students in the section taught by the full-time faculty member ranked the course either a 4 or 5 on a five point scale for the overall learning experience. In comparison, 71% of students enrolled in all other science courses taught that semester rated their overall learning experience to be a 4 or 5.

Students rated Exploring Science as a significantly better learning experience overall compared to all science courses offered in Spring 2005 (t (11) = 14.28, $p < 0.001$). These differences were significant when adjunct faculty taught the course in Fall 2005(t (11) = 8.03, $p < 0.001$). For both adjunct-taught sections, 83% of students gave their overall learning experience a high rating (4 or 5 on a five point scale) compared to 65% for all other science courses taught that semester. One semester following course completion, students reflected on which aspects of the course they had used on their own (Table 2).

Students in the pilot course (Spring 05) reported learning gains that were statistically significant for Confidence in Critical Thinking (t (7) = 4.20, $p<0.006$), Interest (t (9) = 4.08, $p<0.004$), Involvement (t (9) = 8.93, $p<0.0001$), and Overall Attitude Towards Science (t (6) = 8.77, $p<0.0001$) (Fig. 2). Involvement had the largest gain. Students were able to practice scientific skills that contributed to a civic process by collecting lead data for clients following EPA guidelines, regularly sharing data with friends, family and the general public and debating relevant public health policies.

Student learning gains for the second and third time the course was taught were statistically significant in Confidence in Critical Thinking (t (22) = 5.48, $p<0.0001$), Involvement (t (19) = 2.15, $p<0.05$) and Attitude Towards Science (t (18) = 3.24, $p<0.005$)(Fig. 3). Interest, however, did not change from pre to post test. This finding will be addressed in the discussion section in more detail.

Examining the trends for each of the four variables in more detail, we analyzed the means across all three classes for each of the questions that composed each variable. Critical thinking skill development significantly increased for all students enrolled in Exploring Science for questioning, evaluating, analyzing, and communicating scientific concepts (Table 3). The focus on the hands-on applications of collecting, comparing, evaluating, analyzing, composing and organizing real-world data resulted in significant learning gains. As one student commented, "Field labs helped me learn the most because I am a hands-on type of learner, as are many of the students in this course. We learn by doing". Gathering and analyzing scientific data were the two most important critical thinking skills that students identified as helping their learning (Table 4). However, it is very significant to note that all the critical thinking skills listed in Table 4 had a mean of four or more on a five-point scale. For a required non-science majors' course, this finding is crucial for fostering scientific literacy beyond the classroom. Students not only gained confidence in using critical thinking skills in science, but also recognized the importance of such skills in enhancing their own learning process.

Students in all three classes reported gains in civic involvement in scientific issues. Students indicated that after completing *Exploring Science* they were more likely to read, volunteer, contact a public official, vote, debate or attend a community meeting on a scientific issue (Table 5). Their likelihood to engage in an informal scientific discussion did not change and their reported likelihood of discussing civic or political issues decreased significantly. This is a surprising finding given that students reported both increased confidence and interest in discussing these issues. In further analysis of the data, there is a difference in response by type of instructor. Students in the adjunct-taught classes reported that they were less likely to engage in informal scientific or civic discussions after completing the course; whereas those in the full-time instructor class reported an increased likelihood to engage in these discussions (Q3.1: $t\ (33) = 2.11$, $p < 0.04$; Q3.2: $t\ (34) = 2.61$, $p < 0.01$).

Student reported gains in Science Interest did not increase uniformly for all three classes. In comparing initial pre-test ratings, students in the pilot section in Spring 2005 had a low interest in science (Fig. 2, mean of 1.5); whereas for the two following classes in Fall 2005 pre-test interest level was higher (Fig. 3, mean of 2.1). In disaggregating the data further, student level of interest in discussing scientific concepts with family and friends (Q2.1) was the only individual question that increased significantly for all students enrolled in *Exploring Science* regardless of instructor (Table 6).

Discussion

Using an inquiry approach to address national public health issues increased students' confidence in using critical thinking skills. Students reported they were better able to question, analyze, compare, synthesize and evaluate the relevance of scientific data from multiple sources. Other researchers found that both science majors and non-majors performed better on laboratory practical examinations and wrote better discussions if they had inquiry-based instruction compared to traditional verification only experiences.[20] Skills that did not change were interpretation of tables and graphs, understanding mathematical formulas, finding scientific articles and extracting main points (Table 3). These basic mathematical and science research skills are emphasized in the required general education math courses as well as in the pre-requisite science course, *Environmental Science* (Exploring Science is the second course in the two-course science sequence in general education.) After completing *Environmental Science*, students clearly felt that they had mastered these basic scientific skills and had a high confidence level in their ability to understand the scientific content of the second course as evidenced by the pre-test mean of 3.62 on a five point scale.

By making the learning process overt, students were able to discuss how they learned scientific information as they were learning it. They were better able to see and interpret meaningful patterns by building on their own strengths as well as to discuss alternative learning strategies to compensate for areas in which they did not typically excel. They questioned and observed the expertise of other students in the group. For example, in practicing for the final oral presentation the two students who were the best aural learners guided the rest of the group in presentation skills; whereas the best read/write student edited and provided comments on the draft written report. Sojka[21] found that learning is more permanent when students are involved in the learning process itself.

Civic engagement is critical to the democratic process. Researchers[22] found that undergraduate students need to examine the social consequences of scientific research in order to analyze and articulate multiple viewpoints. By directly engaging with EPA staff and clients to measure lead levels, students in our course were able to directly participate in a scientific process which feeds into community application. They experienced firsthand the intersection of policy, social, environmental, economic and scientific debate on the most critical environmental issue to children in the United States. When challenged to do more, they rose to a higher standard so that the final product was a replicated scientific assessment of high quality. By doing science themselves they were better able to understand the limitations and strengths of the process and, at times, the frustrations associated with high-caliber research.

We did not find consistent student gains reported for interest in science. The majority of the individual questions that composed the Interest variable on the national survey were aimed at students who intended to pursue science as a career (Table 6, Q2.4 to 2.9). Our student population was composed entirely of non-science majors who are enrolled in the course because it is a general education requirement for graduation. They were upper-level students majoring in highly technical and tightly sequenced programs such as fashion merchandising or graphic design and were completing their last required science course for their degree program. It was not surprising to us that they had no intention of taking an additional science course, changing their majors or shifting their career goals after the substantial investment they had already made towards learning their chosen profession.

For the remaining questions, there were discrepancies in student responses for survey questions that appeared to ask the same concept, but in two different ways. For example, students in all three classes reported significant gains when asked if they were interested in discussing scientific concepts with their friends and family (Table 6, Q2.1), but did not report any gain at all or in one case reported a decrease in interest when asked if they are more likely to discuss a science-related issue informally (Table 5, Q 3.1) or discuss a civic or politically related issue informally (Table 5, Q 3.2). It is unclear if this discrepancy was due to the way the questions were worded on the pre- and post-test. On the pre-test students were asked how often they engaged in informal discussions, whereas on the post-test they were asked to rank how likely they were to engage in a discussion. It appears that the students did not equate discussing a scientific issue with family and friends as the same as an informal discussion.

Finally, for both of the informal discussion questions (Table 5, Q3.1 and Q3.2), there was a difference in student reported gains by instructor. Students in the full-time faculty section reported gains on both of these questions, whereas those in the part-time faculty sections reported either no gain or a significant decrease in informal discussions in civic and political issues. We hypothesize that these differences could be due to the fact that the full-time faculty teaching the course had considerably more experience in community-lead science projects on civic issues and also were the original developers of all the course materials. While the part-time faculty who taught the course had been given extensive training in science pedagogy, they did not have the same background to draw upon.

For future work, we will revise and add additional questions to target interest level as well as conduct a more detailed follow-up survey of behavioral changes. Based on student qualitative feedback throughout the course and one semester afterwards, we see anecdotal evidence that students were able to see the relevance and use of science in their everyday lives. Demers[23] found that students were more likely to take an active role in the science classroom if the issues were connected to their personal or professional lives.

Conclusion

Significant learning gains in confidence in critical thinking skills and civic involvement in scientific issues resulted from using an inquiry-based approach to science pedagogy that focused on unsolved national public health issues. While we have anecdotal evidence during the course and one semester afterwards that students were using these skills in making daily lifestyle decisions, an important next step would be to measure actual behavioral changes in health choices as well as civic engagement made by students and their families as an outcome of such an approach to science education.

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Table 1. ***Student Reflections on What Element of the Course was Most Important***

Course Objective: I am an effective learner

The different learning styles was the most important. Constantly working as a group had the greatest impact on me.

The learning aspect. Being able to use it in everyday life. The (childhood) lead (poisoning) portion because we tested real-life situations and applied them. I learned the seriousness of the problem.

I liked how it was our project from the beginning to the end. We really created something and became very knowledgeable. It was very rewarding.

I really enjoyed the student/teacher relationships and the overall atmosphere of the classroom. We were able to feel comfortable with the teachers while still truly learning and as I said before the childhood lead poisoning unit was what impacted me the most. I honestly had never thought twice of the possible effects of lead.

I know you want something more specific to work with, but honestly I just cannot pick. I feel that everything about this course was very important to me. I would even go so far as to say that I feel it should be mandatory for all students at this school.

Course Objective: I am a critical thinker

All of them (the modules) really because each one was a topic that affects us all on a day to day basis. These are the things that we will now consider when making simple decisions each day. It's actually weird because now I preach what I have learned.

Analyzing our samples from gathering them to digesting them to presenting our data (on childhood lead poisoning to clients with children). Very good learning process.

I feel that what we learned in the labs is something that I think about daily. When I sit down to eat I can picture the lab where we measured out the sugar and fat content of each item and remember the Super Size Me video.

Course Objective: I make a difference

The lead study was the most important because it spanned the confines of the classroom and made us feel important in other's (client's) lives. The greatest impact on me was the obesity module as many new lifestyle choices have been made as a result. By giving up McDonalds and soda, I've lost 9 pounds since we covered that unit.

The obesity (module) was very important to me. The majority of my family is overweight and I feel like have more knowledge to help prevent it in me. Also the (drinking) water (quality) because now I know what I am drinking. Pesticides had the greatest impact because now when I eat I think of all the pesticides I'm eating.

Learning about the health impacts and what can harm my body. They were all very impacting.

It actually helped me maintain a healthy diet

The fact that science is tied into our everyday lives. That we learned how much it affects me and that I really enjoyed it enough to pass it on to others.

Table 2. ***Student Comments on Course Impact One Semester After Completion***

I am a Dual Major in Fashion Merchandising and Marketing in the School of Business Administration. I am currently a junior and will be graduating next year. I have used a lot of the information we learned in Exploring Science in my everyday life. Not only have I brought issues about the environment up in class about water quality (that bottled water isn't that much greater than tap water) and about recycling plastics and paper, but I am much more aware of my consumption in my everyday life. I try to cut down on my use of water, oil, paper and plastics because I know that these things are eventually going to run out. I also am much more aware of the issues with lead and will use that information down the line when I am raising children. I am also going to try to buy a hybrid car when I am ready or, hopefully, we will have a new technology out by that time that will cut down even further on our reliance on overseas oil. I am sincerely glad that I took that class, it will definitely be much more helpful in my life than one of the other Science II courses.

I'm a Fashion Design sophomore. I'm more aware of what's around me, the smoking lab made me more conscious of who I'm around (restaurants, parties, etc), the sunscreen lab reiterated the need to apply and re-apply sunscreen, and most especially, the fast food lab opened my eyes to avoiding or making healthier choices when going out to eat.

My major is Psychology with a minor in business, I am a sophomore. The exploring science course that I took helped me with researching a specific subject and following through with conclusions on the information that was found. In specific I am referring to the Lead Project; I definitely feel that the most was learned from that project in respect to the course.

I'm a Fashion Merchandising sophomore. After doing the lab on smoking and second hand smoking, I have cut back on smoking and am trying to quit. Also, after watching the film on *Super Size Me*, my intake of fast food has decreased. The class was very interesting and I liked the fact that the labs were hands-on. I feel that this class should continue because what I have learned and experienced I've used in my life.

I am a sophomore and a Finance major. From class I learned a lot about skin cancer which is important since my father suffered from it. I also thought the smoking subject was very important too.

I'm a Fashion Merchandising sophomore. I have used ideas from Exploring Science in my everyday life. The smoking lab that we did, in addition to the movie and discussion has made me think more about the effects that smoking has on your body and others. I have tried to get my mom to quit repeatedly, especially after the class's lectures and assignments, but it hasn't worked yet. I also don't eat McDonalds! I wasn't a big fan of it before and I am definitely not a fan of it now (meat- wise). I do have to say though, their Oreo McFlurry's are an exception! The class was one of my most interesting and fun class at Philadelphia University so far. We learned a lot and our professor was even a better plus!

I am a Graphic Design Communication senior. I actually used the section on smoking and my Honors upgrade project on smoking cessation as the basis for my capstone project for graphic design. The other things we learned about water quality, soil, etc I have used in random other projects as well as for my own general knowledge.

Table 3. *Pre and Post Test Means of Student Confidence in Critical Thinking*

	Question	N	Pre Mean (s.e.)	Post Mean (s.e.)	t-value	p
	I am CONFIDENT I can…					
1.1	Discuss scientific concepts with my friends and family	35	3.20 (0.17)	4.09 (0.12)	4.74	.001
1.2	Think critically about scientific findings I read about in the media	35	3.14 (0.17)	4.06 (0.12)	4.94	.001
1.3	Determine what is and is not valid scientific evidence	35	3.17 (0.13)	4.00 (0.14)	4.98	.001
1.4	Make an argument using scientific evidence	35	3.06 (0.18)	3.97 (0.13)	4.72	.001
1.5	Determine the difference between science and "pseudo-science"	34	2.24 (0.18)	3.41 (0.20)	5.75	.001
1.6	Interpret tables and graphs	34	3.65 (0.17)	3.88 (0.14)	1.61	n.s.
1.7	Understand mathematical and statistical formulas commonly found in scientific texts	33	2.67 (0.22)	3.12 (0.27)	1.63	n.s.
1.8	Find scientific journal articles using library/internet databases	34	3.56 (0.17)	3.82 (0.16)	1.56	n.s.
1.9	Extract main points from a scientific article and develop a coherent summary	34	3.62 (0.16)	3.85 (0.13)	1.24	n.s.
1.10	Give a presentation about a science topic to your class	33	3.55 (0.16)	4.33 (0.12)	4.88	.001
1.11	Obtain scientific data in a laboratory or field setting	34	3.50 (0.17)	4.18 (0.13)	4.68	.001
1.12	Understand how scientific research is carried out	34	3.32 (0.16)	4.12 (0.12)	5.73	.001
1.13	Pose questions that can be addressed by collecting and evaluating scientific evidence	34	3.29 (0.14)	3.97 (0.14)	3.81	.001
1.14	Organize a systematic search for relevant data to answer a question	33	3.21 (0.16)	3.85 (0.15)	4.67	.001
1.15	Write a report using scientific data as evidence	34	3.29 (0.18)	3.94 (0.21)	2.67	.012
1.16	Understand scientific processes behind the important scientific issues in the media	34	3.09 (0.13)	3.97 (0.15)	6.09	.001
1.17	Understand the science content of this course	34	3.68 (0.15)	4.29 (0.12)	3.45	.002

Table 4. ***Which Aspects of the Course Helped Your Learning?***

Question	N	Mean	s e
1. Addressing real-world issues	35	4.3	0.75
2. Interplay between science and civic issues	35	4.0	0.96
3. Gathering scientific data in lab or field	35	4.4	0.81
4. Analyzing scientific data	35	4.5	0.60
5. Using scientific methods	35	4.1	1.01
6. Learning scientific facts	35	4.2	1.04
7. Learning how real science is done	35	4.2	0.83
8. Summarizing scientific facts	35	4.2	0.92

Table 5. ***Pre and Post Test Means of Student Civic Involvement in Scientific Issues***

	Question	N	Pre Mean (s.e.)	Post Mean (s.e.)	t-value	*p*
	I am more likely to…					
3.1	Discuss a science-related issue informally	34	3.91 (0.23)	3.70 (0.18)	-0.80	n.s.
3.2	Discuss a civic or political issue informally	34	4.18 (0.21)	3.44 (0.20)	-2.93	.006
3.3	Read a science-related magazine not required by class	34	2.35 (0.25)	2.94 (0.19)	2.23	.033
3.4	Write a letter or emailed a public official about a civic or political issue	33	1.48 (0.16)	3.06 (0.36)	4.24	.001
3.5	Write a letter or emailed a public official about a science-related issue	34	1.29 (0.24)	2.97 (0.35)	3.94	.001
3.6	Talk with a public official about a civic or science-related issue	34	1.47 (0.24)	3.15 (0.35)	5.87	.001
3.7	Debate or offer public comment on a scientific issue	34	1.94 (0.30)	3.26 (0.34)	4.32	.001
3.8	Debate or offer public comment on a civic or political issue	34	2.15 (0.32)	3.15 (0.36)	2.96	.006
3.9	Attend a meeting, rally, or protest about a civic or political issue	32	1.56 (0.27)	2.94 (0.32)	3.16	.003
3.10	Write a letter to the editor about a civic or political issue	33	1.33 (0.26)	2.79 (0.31)	3.34	.002
3.11	Write a letter to the editor about a science-related issue	33	1.30 (0.24)	2.73 (0.32)	3.36	.002

Table 6. ***Pre and Post Test Means of Student Interest in Science***

	Question	N	Pre Mean (s.e.)	Post Mean (s.e.)	t-value	*p*
	I am INTERESTED in…					
2.1	Discuss scientific concepts with my friends and family	34	2.85 (0.18)	3.47 (0.18)	3.27	.003
2.2	Reading about science and its relation to civic issues	34	2.88 (0.18)	3.15 (0.16)	1.55	n.s.
2.3	Reading articles about science in magazines, journals or on the internet	34	2.50 (0.19)	2.74 (0.17)	1.39	n.s.
2.4	Taking additional science courses after this one	34	2.18 (0.33)	2.65 (0.34)	1.21	n.s.
2.5	Majoring in a science-related field	33	1.82 (0.35)	2.33 (0.41)	1.18	n.s.
2.6	Exploring career opportunities in science	33	1.82 (0.34)	2.00 (0.30)	0.39	n.s.
2.7	Joining a science club or organization	34	1.62 (0.26)	1.82 (0.28)	0.56	n.s.
2.8	Attending graduate school in a science-related field	34	1.94 (0.40)	2.09 (0.36)	0.36	n.s.
2.9	Teaching science	34	1.85 (0.39)	1.76 (0.35)	-0.20	n.s.

Figure 1.

Figure 1. Mean student rankings on university evaluations for Exploring Science compared to all science courses taught for two semesters.

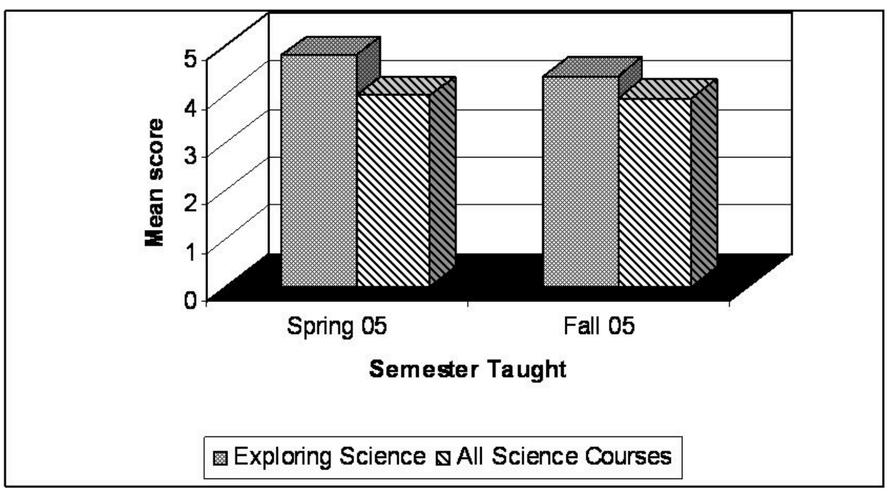


Figure 2.

Figure 2. Student reported gains for Exploring Science pilot section taught by full-time faculty in Spring 2005 (N=10)

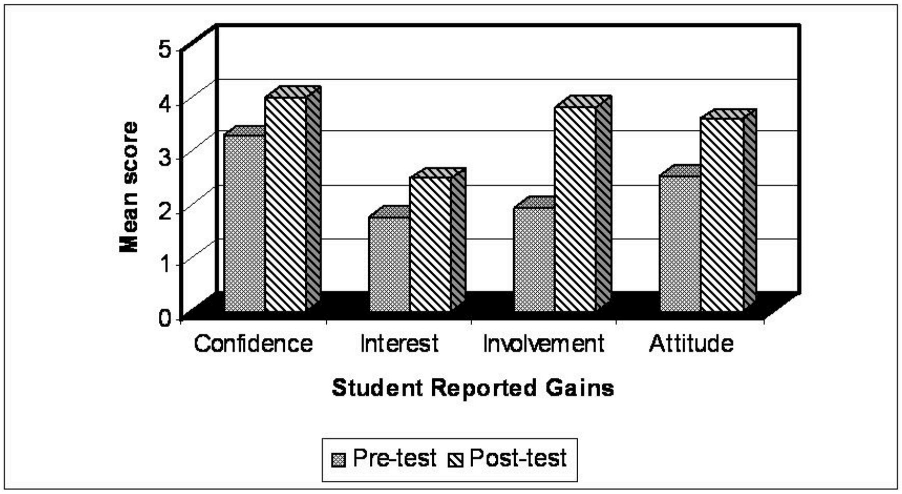
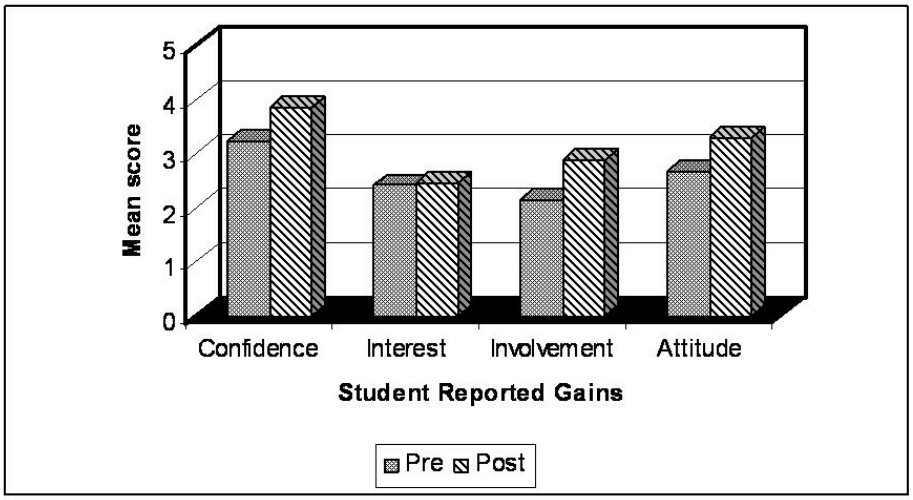


Figure 3.

Figure 3. Student reported gains for Exploring Science taught by adjunct faculty in Fall 2005 (N=25)



Books, Media, and Exhibits

Book Review: *Learning to Think* by Janet Gail Donald

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Why don't my students know how to write? Why can't the chemistry majors in my physics class solve problems? And when will we start getting students who understand how an engineer thinks?

Janet Gail Donald sheds light on these perpetual complaints in her book, Learning to Think. Based on 25 years of research, this book describes the ways that varied disciplines view thinking, and the thinking processes and behaviors that different disciplines privilege. Interviews with faculty and students, correlated with classroom observations, helped to illuminate the methods of inquiry in the studied disciplines and revealed how they organize knowledge, define and represent concepts, and determine validity.

Starting with physics, which she names "the prototype or model discipline," Donald analyzes the "concepts, thinking processes, and attitudes that professors consider important." She also considers student perceptions of learning in this field, seeking to confirm or refute the faculty perspectives on how one best learns physics. She then poses three questions about learning in physics, an approach she applies to each of the disciplines she studies:

1) How can we help students develop the necessary conceptual framework in this discipline that is abstract and counter-intuitive?

2) Then, how can we improve students' ability to problem solve?

3) And finally, what approach do students need to take in order to learn this discipline successfully?

What makes this book a valuable read for any faculty member, particularly those in the STEM fields, is that in attempting to answer the above questions, she pairs cognitive theory with intense study of teaching and learning in specific disciplines. In the process, she articulates, in unambiguous terms, the ways of thinking and knowing that comprise disciplinary culture. This insider knowledge is seldom shared directly with students, most likely because of the inculturation of scholars and teachers in the field (i.e., faculty); that is, they may not even be consciously aware of ways of thinking and knowing in their discipline or consider the fact that this knowledge can and should be part of students' education. Rather, the sensing of such disciplinary culture is a measure of whether a student "belongs" in the discipline. By making this information transparent to the reader, Donald provides faculty with ways to open the doors of their subject to students who don't naturally think the way the faculty do. Such insights are particularly important for those who teach and learn at the intersections between disciplines, or for interdisciplinary work, where one cannot fall back on one's disciplinary assumptions because these are not necessarily shared. When that interdisciplinarity spans not just related disciplines such as chemistry and physics, but a much broader span, such as hard science and economics and public policy, as it does in the study of climate change, those participating must consciously address the biases and limitations imposed by their own approaches to thinking.

For all the STEM disciplines studied -- physics, engineering, chemistry and biology -- Donald catalogs how each field approaches what she has identified as six critical aspects of the problem solving process: description, selection, representation, inference, synthesis, and verification. As someone with graduate degrees in both physics and engineering, I struggled in my early graduate engineering courses, because I tried to use the approaches I had employed in physics courses, which were ill-suited to the less-structured problems common in engineering courses. It was reassuring to find that there was a real basis for the difficulties that I had in moving between classes in these two closely related fields – the varied ways in which the fields approach problem solving, and the different values the two fields hold. I hope that having experienced such difficulties has made me a better teacher, one more cognizant of some of the frustration that students experience. But I had not grappled with the complicated ways in which this might affect students until I was presented with the subtle yet significant differences that each discipline brings to the question of "thinking."

This book helped me think more deeply about how to teach thinking, both through a better understanding of how my own disciplines define and ask for demonstration of thinking, and by making clearer the ways in which non-STEM disciplines view it. Donald provides an institution-wide perspective on the process that we all seek in students, and yet often take for granted. We forget that the types of thinking we seek are neither universal nor "obvious to the most casual observer." Reading this book is a powerful reminder that disciplinary approaches are indeed "disciplinary," and that the lack of transfer of the processes of thinking from one class to another, and across the disciplinary boundaries, reflects less a failing in the students than a weakness in our educational structure.

Learning to Think is not an easy read, and that too is powerful, reminding readers that the concept and reality of thinking is not simple. The subject material is complex, and sometimes challenges the ingrained beliefs of the reader, particularly if she comes from one of the disciplines closely examined. The book's language reflects the background of its author (education), and may be rather foreign to STEM faculty members. Yet, despite the determination needed to digest this work, it is worth the effort. For those in need of motivation, the last chapter on Learning, Understanding, and Meaning, provides some synthesis of the many disciplinary perspectives and concrete suggestions that faculty can incorporate into their classrooms immediately. The tables (Exhibits 9.4 & 9.5) of "Most Important Thinking Processes used Generally across the Disciplines" and "Comparison of Challenges to Instruction across the Disciplines and Responses to Them," could be terrifically valuable for new faculty members. And because it provides an institution-wide perspective that students almost never get, the insights from her work would be a great addition to the transition to college courses that abound for first year students these days.

Over 90% of college faculty members agree that critical thinking is the most important aspect of undergraduate education, so, it is crucial for them, both as individuals and as members of a department, to come to some understanding of this topic. Learning to Think provides the background, insight, motivation, and perhaps a challenge for faculty – to deal with this cornerstone of higher education as thoughtfully as they do their disciplinary research.

Darwin: An Exhibit at the American Museum of Natural History[1]

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What Can Charles Darwin Teach Us About Science?

In October 2004, the Dover School Board of Directors passed a resolution requiring that "students will be made aware of gaps/problems in Darwin's theory and of other theories of evolution including, but not limited to, intelligent design." The Board then drafted a statement to be read by teachers to the ninth grade biology class, which stated (in part) that "Gaps in [Darwin's] Theory exist for which there is no evidence" and that "Intelligent Design is an explanation of the Origin of Life that differs from Darwin's view."[2]

Controversy over Charles Darwin's groundbreaking work on evolution is nothing new. Almost 150 years have now passed since Darwin first published On the Origin of Species By Means of Natural Selection, in which he argued that biological organisms are not static creations but are the result of evolutionary adaptation under the pressures of natural selection. We are all familiar with the flashpoints of controversy over Darwinian evolution – the debate between T.H. Huxley and Bishop Samuel Wilberforce in 1860, the trial of John Scopes in 1925. In recent years there has been a surge of anti-evolution activism within local and state school boards, whose members have attempted to cast doubt on Darwin's insights and have promoted the teaching of "alternative" explanations of life's diversity such as "intelligent design." The Dover School Board resolution was a well-publicized example of this growing national trend.

This decision prompted eleven parents of Dover schoolchildren to file a civil suit against the Dover School Board, which was heard by Judge John E. Jones III (Kitzmiller vs. Dover Area School District). The plaintiffs contended that the statement promoted creationism and therefore violated the constitutions of the United States and Pennsylvania. Much of the court testimony focused on the following question: Can intelligent design be classified as "science?" Only an affirmative answer would allow intelligent design to be discussed in a science class as an "alternative" to "Darwin's Theory."

If you were asked to define what is meant by "science," what would you say? What would your students say? Many science textbooks provide a perfunctory overview of the "scientific method," which some students diligently memorize. But these textbook descriptions often seem sterile and do not capture the complexity of scientific creativity, uncertainty, analysis, and debate. As a teacher of large science classes for students who are typically majoring in the arts and humanities, I regularly face the challenge of trying to provide a realistic portrayal of the scientific process. One approach is to examine the struggles, successes, and failures of exemplary scientists; for this purpose, it would be hard to find a better case study than Charles Darwin.

So many books and articles have been written about Darwin that it has been called the "Darwin Industry." But these publications reach only a fraction of the population, often those who are already interested in Darwin and his ideas. A different way to reach the public is through museum exhibits. In fact, museums provide one of our most important "civic spaces," creating unique environments and opportunities for learning that cannot be matched by other approaches. For this reason, I eagerly anticipated the extensive new exhibit on Darwin's life and work which opened in November 2005 at the American Museum of Natural History. There is a comprehensive website associated with the exhibit that can be accessed at www.amnh.org/exhibitions/darwin.

What can Darwin teach us about science? As I walked through this outstanding exhibit, I developed an even greater appreciation of the ways in which Darwin's life and work serve to illustrate the complexities of scientific inquiry - a process of observation, analysis, hypothesizing, and insight that is embedded within a personal and societal context. The first objects I encountered in the exhibit were two of Darwin's prized possessions: a magnifying glass and a notebook. These simple objects served him well during his long career as a scientist. The magnifying glass reappears at key points throughout the exhibit, inviting us to join Darwin in "looking closely" at the natural world (Figure 1). Looking closely is something Darwin did very well: During the course of his scientific career he completed over 80,000 pages of notes that were used as the basis for 16 books and 150 papers.

Including this short introduction, the museum exhibit is organized into eight sections that show how Darwin slowly came to reject the view that species were immutable creations and instead developed his own theory of evolution by natural selection. The major stages of this journey are well-known: Darwin's inauspicious attempts to become a physician and then an Anglican minister; his five year voyage on The Beagle; his painstaking analysis of how species vary in morphology and geographic distribution; his reluctant publication of the Origin of Species; and his tortured personal struggle with the spiritual implications of his theories. All of these episodes are effectively captured by various displays within the exhibit.

From my perspective, the most vivid insights into Darwin's scientific creativity are provided by the section entitled "The Idea takes Shape." After the HMS Beagle returned to England in October 1836, Darwin immediately began writing extensive notes about his observations. Around July 1837, Darwin sketched his first crude "evolutionary tree," with ancestral organisms at the bottom of the picture and their descendants branching at the top (Figure 2). At the top of the page he wrote "I think." This sketch captures one of Darwin's most profound insights about evolution but also his sense of uncertainty about this new idea. By late 1844, however, Darwin had converged on the principle of natural selection as the mechanism for driving the evolution of species; he later wrote that that the idea felt "like confessing to a murder."

Another highlight of the exhibit occurs near the end in a section on "Evolution Today," which shows how Darwin's insights on evolution are supported by a convergence of different types of modern scientific evidence. Interactive screens allow us to compare anatomical structures in different organisms, illustrating the evolution of different species from a common ancestor. We are introduced to the rapid evolutionary change of bacteria and the ways in which scientists are using DNA evidence to construct evolutionary relationships between organisms. Based on my teaching experience with students, the recent development of drug resistance in viruses and bacteria provides one of the most effective illustrations of evolution by natural selection.[5] A set of videos provide short commentaries on the current controversies surrounding evolution, with contributions by curator Niles Eldridge and Francis Collins (Director of the National Human Genome Research Institute). Kenneth Miller of Brown University makes one of the most illuminating statements by addressing what scientists mean by a "scientific theory" to dismiss the misleading dichotomy between "theory" and "facts." Miller informs us that "theories never become facts in science. They explain facts." In this context, it is worth pondering how many of our students could carefully explain the relationship between facts and theories in science.

This provides a suitable point for returning to the case of Kitzmiller vs. Dover Area School District. On December 20, 2005, Judge Jones issued a 139-page memorandum stating that teaching intelligent design (ID) in public schools is a violation of the Establishment Clause of the First Amendment and the Constitution of Pennsylvania.[6] "In making this determination," he wrote, "we have addressed the seminal question of whether ID is science. We have concluded that it is not, and moreover that ID cannot uncouple itself from its creationist, and thus religious, antecedents."[7] Why does intelligent design fail the test for being a science? According to Judge Jones, it "…cannot be adjudged a valid, accepted scientific theory as it has failed to publish in peer-reviewed journals, engage in research and testing, and gain acceptance in the scientific community."[8]

At a time when teaching evolution has again become controversial, Darwin's life and work can provide important lessons for us and our students. Darwin's ideas have been scrutinized and challenged for almost 150 years, but his core insights into evolution by natural selection have stood the test of time and become a foundation of biological science. To be sure, these ideas have been modified and extended to account for new discoveries that were unimaginable during his lifetime. In fact, this is an exciting time for scientific studies of evolution: Science magazine announced "Evolution in Action" as its breakthrough of the year for 2005.[9] Contrary to the claims of proponents of intelligent design, these modern developments further illustrate the strengths, not the weaknesses, of Darwin's insights, As I left the museum exhibit, I was left with one image that captures what Charles Darwin can teach us about science…. two scribbled words saying "I think."

References

1.The Darwin exhibit was curated by Dr. Niles Eldrige, a staff member at the American Museum

of Natural History. The website for the exhibit It has already been shown at the AMNH in New York (November 19, 2005 - May 29, 2006) and the Franklin Institute of Science in Philadelphia (October 6, 2006 - December 31, 2006); its next two stops will be the Museum of Science in Boston (opening February 18, 2007) and the Field Museum in Chicago (opening June 15, 2007).

2.All quotes about the Dover School Board case are taken from the Memorandum Opinion written by Judge John E. Jones III on the case of Kitzmiller v. Dover Area School District (December 20, 2005). The complete memorandum can be obtained from http://coop.www.uscourts.gov/pamd/kitzmiller_342.pdf (Retrieved April 12, 2006). The first quotes are from pp. 1–2 of the memorandum. An interesting account of the case is provided by H Allen Orr, "Devolution: Why Intelligent Design Isn't," New Yorker, May 30, 2005. Available online at http://www.newyorker.com/fact/content/articles/050530fa_fact (Retrieved December 10, 2006).

3. Retrieved December 20, 2006 from American Museum of Natural History Web site: www.amnh.org/exhibitions/darwin/intro/magnifier.php.

4.Retrieved December 20, 2006 from American Museum of Natural History Web site: www.amnh.org/exhibitions/darwin/idea/think.php.

5.The evolution of HIV is addressed in a segment of a NOVA video entitled Darwin's Dangerous Idea. Information about the video and a teachers guide can be found at www.pbs.org/wgbh/nova/teachers/programs/0000_evodarwi.html. Retrieved December 20, 2006.

6.A useful one-page summary with excerpts from the decision is provided in *Science*, *311*, 34 (2006).

7.Kitzmiller v. Dover Area School District, p. 136.

8.Kitzmiller v. Dover Area School District, p. 89.

9.Culotta, E. & Pennisi, E (2005). Evolution in Action. *Science, 310*, 1878–1879.

Figure 1. ***Darwin's magnifying glass and notebook.***[3]

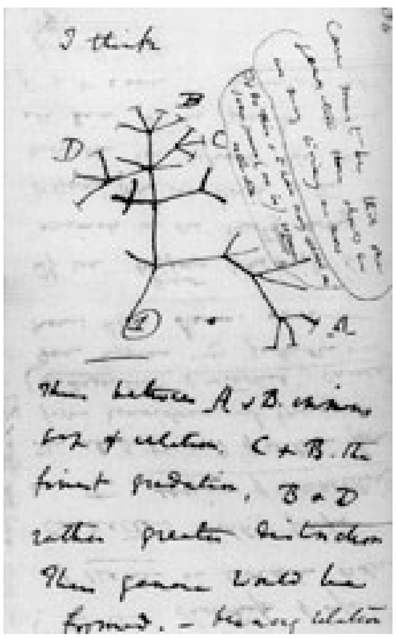

Figure 2. ***Darwin's first notebook sketch of an evolutionary tree showing the relationship between species descended from a common ancestor. At the top of the page he wrote "I think."***[4]