

Developing Active Role of Science Museum in Educating on Ethical Issues on Science and Technology: Four Case Studies¹⁾

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ABSTRACT

The purpose of this study was to examine a) each of the selected science museums for its role in educating on ethical issues in science and technology, b) what are the most frequently dealt ethical themes in science and technology; c) how were those themes presented (via exhibition, play, panel, movies, etc); and d) identify common characteristics in the selected science museums' presentations of ethical issues.

The results indicated that selected museums present ethical issues related to technology development, mainly on biotechnology and environmental issues. The type of presentations dealing with ethical issues most frequently were exhibitions, panels and simulations, followed by demonstrations and lectures. All of the selected museums had common characteristics for actively taking an educational role in ethical issues in science.

The study suggests that efforts to communicate the ethical issues in various areas should be reinforced to educate students and the public, and that it may be the museum's role to expose ethical aspects of technology related to human rights, dignity, health and development issues from the early stage of its development.

Key words: science museum, ethical issues, science and technology

I. Introduction

Informal learning in science takes place in a variety of contexts and learning outside of formal institutions is become to be very important in relation to the formal school curriculum (Wellington, 1990). One of the founders of the San Francisco Exploratorium, Frank Oppenheimer, the brother of Robert Oppenheimer, emphasized the value of informal learning in promoting science education and science itself, as opposed to formal education (Wellington, 1994).

There is a great variety of sources to obtain educational experience of science outside of the school curriculum (Wellington, 1994; Anonymous, 1998). The media can also be an effective source for science education, such as television programs, radio, newspapers, film, and the internet. Visiting science museums or science centers, natural history museums, planetariums, zoos and aquariums, botanical gardens and parks, nature centers and environmental education centers, and scientific research laboratories—they can all be practical learning experiences. Community-based organizations and projects, including youth organizations and community

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outreach services, could also be places for science learning and education. In a relatively short time, an impressive number of science centers have developed and increased in every country, each with their unique distinctive characteristics and emphasis in science (Song, Oh, Cho, & Koo, 2002). As social education and continued education have become more emphasized, education has also become the central part of the museum's role.

As the museum's role has expanded from a simple display of objects, it has developed its own significance at the social, economical and political level (Song *et al.*, 2002). These may be the reasons why science centers are growing rapidly in recent years. In terms of the societal or cultural level, it helps people to understand the evolving technologies in science and to predict the consequences of these developments in the future, based on human development, dignity, right and other ethical issues. In this aspect, the science museum is the place where people can obtain objective perspectives on various facets of scientific development and further develop insights on the ethical, legal, and societal issues.

Another important aspect of museums lies at the economical level. The locations or the towns where science museums are built gradually gain popularity and recognition and gain significant economic advantage. Often the town of the museum develops into a sightseeing place, inviting other supplementary facilities near the museum, offering the locals opportunities to open up small businesses, and lastly attracting many visitors and museum-goers. At the economical level, museums can easily be managed independently by running little shops selling museum items and souvenirs.

Lastly, museums have significance at the political level. Museums contribute in educating the public with national history, cultural characteristics, traditional customs, and further reinforcing the national pride with national identity. The main reason the nation is investing a great portion of the budget into building museums is maybe due to such political significance. In other words, a museum with national recognition helps growing children to have pride as citizen of the nation, and helps them gain a further sense of cohesiveness within the nation.

Although the museum has significance for the society and the nation in various aspects, museums are expanding their educational roles for the public. It is stated that "if the collections are the heart of the museum, then the education is its spirit" (AAM, 1984). Many of the science museums call themselves "public educators" and have changed from exhibits of displays to places for hands-on experience and active participation. Such efforts imply that museums will take an active role and participation in educating the public and future generations with sound attitudes towards science and assist them to develop analytic insights on science and technology.

Henriksen and Frøland(2000) have suggested a few challenges that museums should consider. They suggested that museums should serve to be public service institutions, meeting places, arenas for public debate, dialogue institutions, and contributors to the resolution of global challenges. On the individual level, museums should facilitate meetings and dialogues among visitors, where families and friends go to spend quality time together conversing on the presented issues (Falk, 1998; Falk and Dierking, 1992). On the institutional level, museums should function as institutions to provide opportunities for different interest groups to meet and interact, for instance, through arranging public debates or workshops on current science-related issues.

A museum being a dialogue institution also means responding to current issues in society, using the museum's expertise and collections to throw light on these issues. Henriksen and

Frøland (2000) stated that these new goals are very much in line with the practical and civic aspects of scientific literacy.

Ethics in technology has become a critical area for research. Scientist and educators look into the connection between human living and technology and draw ethical quandaries. Therefore, modern science museums must play an efficient and active role to educate the public regarding contemporary science and communicate the ethical perspectives of development in science and technology (Ruggiero, 2000). In recent years, science museums have exhibited various issues in science development and provoked further controversy (Levidow, 1998). Therefore, this study examined four internationally known museums in terms of exhibitions and programs they have in order to educate the public on the ethical aspects on science and technology. The purpose of this study was to examine a) each of the selected science museums for its role in educating on ethical issues in science and technology, b) what are the most frequently dealt ethical themes in science and technology; c) how were those themes presented (via exhibition, panel, plays, tour, movies, etc); and d) identify common characteristics in the selected science museums' presentation of ethical issues.

II. Method

This study purported to examine the museum's role in educating the public on ethical issues in science and technology. Four internationally known museums are selected for this study and further analyzed in terms of exhibitions and programs they have in order to educate the public. These museums were visited and additional information was gathered from their websites and related articles. The selected museums were the Science Museum in London, La Cité des Science et de l'Industrie in Paris, the Museum of Science in Boston and the Deutsches Museum in München. These museums were selected in recognition of their history and size. In order to run various programs and events, it was important to have well-managed websites for public exposure and advertisement, and these museums have met those requirements (Table 1).

Table 1. Descriptive data on the selected museums

	Established Year	Size (m2)	No. of visitors per year	Web site
A	1857	45,000	1,800,000	http://www.sciencemuseum.org.uk/
B	1979	110,000	3,500,000	http://www.cite-sciences.fr/
C	1863	74,487	740,000	http://www.mos.org/
D	1903	33,000	1,500,000	http://www.deutsches-museum.de/

A : Science Museum, London
 B : La Cité des Science et de l'Industrie, Paris
 C : Museum of Science, Boston
 D : Deutsches Museum, München

III. Results

Results showed that the researched museums hold various exhibitions, programs and events dealing with various issues in the ethical aspect of science and technology. The museums

endeavored to provide information on different types of technology including biotechnology, information and communication technology, environmental technology, digital technology, and their ethical aspects from various perspectives, through various exhibits, shows, simulations, activities and lectures. The museums played a role as information provider of the scientific concept itself, and further stimulated public opinion regarding developments and how those perspectives are related to human lives.

The study will first a) provide a general description of each museum, b) specify the most frequently dealt ethical issues, and c) the type of programs dealing with the ethical issues, and lastly the study will also explore potential strategies to educate the public about ethical issues in science and technology.

1. General description of each museum and its programs

The following are collected information on the museum's activities for the ethics education in science. All of them held exhibition, programs and events, and communicated ethical aspect of science development in the educational perspectives. The following are descriptions of educational activities on ethical issues for each of the museums.

A. Science Museum, London

The Science Museum in London hosts a series of debates, events and activities. In the Science Museum, "Wellcome Wing" is a four-story building which is the center for the science of the 21st century. Every floor of the building dealt with various issues in science and technology, and had thought-provoking interactive displays.

On the ground floor, the section named "Talking Points" had a stunning series of thought-provoking exhibits raising questions about the influence of modern science. One of the topics was "Which heart?", pointing out death due to a shortage of human hearts, and suggested possible solutions, such as a mechanical heart and a genetically modified pig's heart. The Wellcome Wing's latest Talking Points exhibit is a new concept in communication - an audio tooth implant that allows you to receive useful information in secret. It allows useful information to be sent to you in secret, wherever you are and whenever you need it. If a surgeon implants a tiny device into one of your teeth, this implant converts data received from a mobile telephone, radio or computer into vibrations, which resonate through your jawbone into your inner ear. And then only the person who has an implanted audio tooth can hear the information. At the moment, no working audio tooth implant exists. But the idea is based on scientific principles.

Also there was a display named "Antenna" which constantly updated an exhibition on science and technology, and included in-depth investigations for the ethical and social aspects related to current science news. SARS, a fat-fighting plant, and first human clone are examples of science and technology news from the last few months in the "Antenna". And war, DNA's 50th birthday, stem cells, and climate change are examples of in-depth investigations in science and technology. This is a continually changing exhibition of 'live' science news, using downloads from the web on a huge electronic bulletin board.

On the second floor, exhibitions named "Digitopolis" dealt with digital technology. The displays included models and lay out of a network for the world wide web. The exhibition has a lot for visitors to see and do, showing how digital technology is changing our lives and how it might

affect us in the future. With Real-time Interactive Digitopolis Environment, if visitors walk through a virtual version of Digitopolis created by computer, they can see how 3-D virtual worlds are created and take their own virtual photographs. This further provoked people's thought on how computer will effect one's life in the future, such as utilizing computer-facilitated house and offices, and their negative outcomes.

The third floor had exhibitions of the future with science development, named "In the Future". These exhibitions presented how our lives will be different from now on with the development of science and technology in terms of clothing, food, electronic devices, home appliances, etc. And in the area of games, visitors can actually explore how science and technology might affect our lives in the future. The games enable visitors to explore technologies that are already being developed. Then visitors can then choose ones that they would like to be part of their life in the future. With other visitors, they decide whether new technological developments - such as space tourism to male pregnancy - should or should not go ahead.

Also, there are various events such as drama and demonstration. Digital dilemma is one of the dramas and there are demonstrations about digital technology. However, we thought the Science Museum in London did not fully introduce the ethical aspects of science. For example, an audio tooth implant in "Antenna" and exhibitions in "Digitopolis" or "In the Future", could imply the social and ethical problems more clearly.

It should be noted that Levidow(1998) also has criticized the exhibit in the London Science Museum. He said that the London Science Museum presents a largely one-sided account of biotechnology as environmentally-friendly, trivializing some of the serious issues which had been long-standing public debate. There were different panels composed of displays. A panel named "Playing with nature" displays flowers and plants in manipulative form. In this section, visitors are invited to push buttons which change traits of flowers.

The "Battle for the Cornfields" is akin to a space invader game which simulates the micro-biologic technique of shooting genes into the cell nucleus. Visitors are asked to participate in saving the cornfield by inserting a poison-producing gene into plants, and then all the plants survive a caterpillar attack. This game is based on BT crops, yet ignores its controversial aspects.

An interactive display "Feeding the world", emphasized the growing world population, which supposedly requires an increase in food supplies and therefore higher productivity. Visitors are invited to design crops by pushing buttons, which simulate genetic modification, for example, for a gene, which protects cassava from virus attack. For the "Technological fix?" display, visitors are told that genetic modification can produce weedkiller-resistant crops despite the ongoing public controversy about how such crops might affect agrochemical usage. This panel reports recent research showing that some weeds may acquire the weedkiller-resistance gene through hybridization. Then visitors are told the ethical issues on this, that more caution is needed in crop management.

Adjacent to the exhibition is the "Ingenious Food Show", whose backdrop includes an enormous tomato and fish. After a plotted history of agriculture, volunteers, usually children, are invited to transfer genes across species. Other volunteers are invited to perform a blind-test of GM and non-GM tomato paste. Overall, the exhibition of the Science Museum implies that our agricultural and food problems arise from genetic deficiencies which can be corrected by precise, familiar techniques for inserting designer genes. But this is not a totally balanced viewpoint.

B. La Cité des Science et de l'Industrie, Paris

La Cité des Science et de l'Industrie makes various efforts to communicate with the public about the ethical aspects of science through exhibits, forums, lectures, debates, workshops, and an on-line web site. The museum is composed of various sections on different types of technology, including the environment, energy, biotechnology, medicine and so on.

Among these, the "Man and his genes" exhibition is composed of four smaller sections: Living Things and Evolution, The role of genes, Genetic Engineering, and Issues for society. All of these exhibitions invited visitors to participate as subjects of study and explore the manipulation of genes. In the last part of the exhibition, "Issues for society", visitors have the chance to put their visit into perspective with an opportunity to participate in a kind of debate. Alone in a booth, visitors can put forward their opinion on genetic tests.

A veritable plant laboratory, the "Greenhouse" is an exhibition devoted to plant biotechnology. This garden of the future is aimed at observing the mechanisms of the plant kingdom, to discover the modern techniques of plant production and to participate in a debate on the issues related to biotechnology. The exhibition consists of three different presentations relating scientific development with human lives: "Challenges and debates", "Artificialising the natural environment and Thinking about nature", and "Weighting your ideas."

The "Biology" exhibition make visitors journey through the microscopic universe of a biological human and learn all about the scientific spin-offs of medical biology. The "Ethics and biology" section in the Biology Exhibition consists of audio books on the ethical questions related to the human body and biology.

As mentioned above, because there were many biotechnology and medicine related exhibitions, much of the ethical quandaries on these exhibits were dealt simultaneously. Strategies to educate ethical issues were formulated via lectures, workshops and experiments. The visitors were asked to be the juries, hearing bioethics cases and casting their vote electronically.

Also, specialists from varied horizons are offering open lectures to inform a better understanding of the issues raised by new developments in life sciences and medicine all year round in the museum. And debates are held based on new developments such as health issues, risk-taking and addiction, cancer, the living world and industry: about the implications of the biotechnology revolution, stem cells and new development in biomedicine: ethics and challenges for society. In debates, biologists, physicians, legal experts, philosophers, sociologists and decision-makers, and public health specialists discuss the ethical, legal and political issues that new developments in biology and medicine pose for human society. Debates are then opened up to the floor.

C. The Museum of Science, Boston

Like other museums, the Museum of Science in Boston has their mission to stimulate interest in, and further understanding of, science and technology and their importance for individuals and for society. To accomplish this educational mission, the museum is dedicated to attracting the broadest possible spectrum of participants, and involving them in activities, exhibits and programs which will encourage curiosity, questioning and exploration, inform and educate, enhance a sense of personal achievement in learning, respect individual interests, backgrounds and abilities, and promote life-long learning and informed and active citizenship. These shows and exhibits are constantly updated to deal with current issues and themes emerging in science

and technology.

The museum holds a variety of events including shows, activities and lectures not just for the children and adults but also professionals who are working in educational settings. They are providing abundant resources for educational material and lectures on science and technology.

The Current Science & Technology Center was launched in April of 2001 as a radically new approach to keep science centers up-to-date with the latest research and discoveries and as a forum for enhancing the public understanding of research. In 2002, "The Clone Show" was introduced, posing such questions to visitors as, "If parents seek to duplicate a dead child, is this madness?", and "Will you clone a baby?". Along with this controversial issue, there was a presentation on cloning to explain what it was about, such as the process of cloning and its success rates and the ethical issues derived from it. Various types of questions are asked and answered during the presentation.

And there are various presentations about current science and technology such as HIV virus, nanotechnology, and the human genome.

D. The Deutsches Museum

The Deutsches Museum in München emphasizes its specialization in the environment exhibitions. Environment exhibitions are related to population, energy consumption, use of raw materials, and our wastes. There are exhibits on forty different areas in science and technology using actual objects, models and other learning materials. The museum holds a regular program, which consists of movies, lectures and simulations. From the ground floor to the fourth floor, the museum displays historical exhibits on technological development reflecting how industrialization took place. There are exhibits on ecology, increasing habitat, energy consumption rates with specific data, further providing the implication of how to mediate the demand between humans and nature. In addition to the environment section, there are sections on mining, bridge building, industrial chemistry, aeronautics, printing, paper, geodesy, microelectronics, weights and measures, astronomy, and musical instruments with emphasis on the acoustical aspects.

These exhibits and displays lead to the final issues of how all these relate to today's environmental concerns. For example, the main controversial issues regarding environmental concerns were product wastes management, pollutant and excessive consumption of energy and other substances, further provided warning of how the earth would be affected if such consumption were continued unabated without any effective solutions. Moreover, they presented the issue of unequal distribution between developing and developed countries in terms of energy, food, and other resources. The environment section reflects Germany's high awareness of environmental concerns and serious contemplation for potential solution, compared to other countries.

2. Most frequently dealt ethics-related themes

Among various issues in science and technology, the most frequently dealt issues were biotechnology (BT), environment technology (ET), and medicine related issues. Besides these themes, there were themes on health, nanotechnology (NT), food, agriculture and digital technology (DT).

According to the following table, it shows that all four museums dealt with biotechnology, environmental technology, and medicine. However, ethical issues related to food, agriculture, health and digital technology were not seen in every museum. On the other hand, in the broad sense, issues in medicine, health, food and agriculture can be included in biotechnology. Hence, one can state that the four museums present ethical issues related to biotechnology more than any other technology.

Table 2. Presented Ethical Themes and Topics in the Museums

	BT	ET	Medicine	Energy	Health	NT	Astronautics	Food	Agriculture	DT
A	○	○	○	×	○	×	×	×	○	○
B	○	○	○	○	×	○	○	×	×	×
C	○	○	○	×	○	○	×	×	×	×
D	○	○	○	○	×	×	○	○	×	×

A : The Science Museum, London
 B : La Cité des Science et de l'Industrie, Paris
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 D : The Deutsches Museum, München

3. Selected type of programs for ethical themes

There are various events taking place in the museums for respective themes and topics, and these events were determined to communicate the issues in the most efficient way. Demonstrations and on-line exhibitions, panels and simulations were the most frequently held event to deal with ethical issues. There were also lectures, plays or shows, debates, and workshops included in the programs. All four museums were actively engaged in searching and developing the most efficient ways to enhance the public's understanding of science related ethical issues. Their web-sites did not just have an advertising function for the museum, but also an educational function in presenting various controversial ethical issues for the society and the public. The following table shows various media of presentation for ethical issues in the science and technology

Table 3. Types of presentation for ethical issues on science and technology

	Panel	On-line Exhibition	Demonstration (exhibits)	Lecture	Play	Debate	Workshop	Simulation
A	○	○	○	×	○	○	×	○
B	○	○	×	○	×	○	○	○
C	○	○	○	○	○	×	×	○
D	○	○	○	○	×	×	○	○

A : The Science Museum, London
 B : La Cité des Science et de l'Industrie, Paris
 C : The Museum of Science, Boston
 D : The Deutsches Museum, München

4. Common characteristics of each museum

From what has been examined and analyzed, there were common characteristics among the presentations and managements of the series which contributed in their success for recognition as world-famous museums. They included age-appropriateness, questions triggering self-inquiry, and constant update of new findings in science and technology. They are discussed individually, below:

A. Age-appropriateness

The age range of visitors for each museum is very wide. Since the science museums are open to the public, they have to hold programs matching all age levels in order to make the experience enjoyable and challenging. For children, the activities were very age-appropriate and fun, whereas for adolescents and adults, the content were enjoyable, challenging and thought provoking. By selecting the most efficient medium for each theme, the programs have taken age-appropriate issues in serious consideration. For example, plays or shows were more frequently used to communicate ethical issues to the children, whereas lectures and panels were targeted for the adults.

B. Questions for self-inquiry and open questions

Science and technology are still developing and it will continue to do so until the “end of the future”. Ethical issues involve not only the identified problems that are existing, but also quandaries of what may happen. Rather than finding the “right” answer to the ethical agenda, it is important to explore them to find the different answers with appropriateness. Therefore, exposure to stimulating questions and exploring creative solutions are significant in ethics education. This also means that providing objective perspectives for certain issues, involving both positive and negative outcomes, needs to be presented in the program.

C. Constant and frequently updated themes and events

Another common characteristic of how these selected museums were run was that they were constantly updating the most recently discovered science and technology findings. There are separate corners assigned to introduce these trends in science, and the Wellcome Wing of the science museum in London, the Current science and technology center in Boston, and Zentrum Neue Technologien in Germany are the obvious examples. The science and technology are developing at a much faster pace than that of developing ethical solutions. Therefore, it is very important to provide the public with appropriate ethical quandaries at the right time. The most immediate role of a museum as a public institute is to be public-friendly and become the informant of technology issues related to everyday living. Therefore, it is important that the ethical themes and issues are constantly updated and reviewed alongside the development of science and technology.

IV. Summary and Suggestions

Many educators and researchers have called for incorporating ethics and moral education into school curricula to enable students to make their own judgments regarding science and

technology related to ethical and moral issues (Cho & Choi, 1998; Maxwell, 1984; Newton, 1988; Reiser & Bulger, 1997; Wakeford & Walters, 1995).

Despite the identified need of teaching ethical issues, ethical education has not kept pace with the rapid and radical developments in science and technology (AAAS, 1993; NRC, 1995). In fact, formal teaching on ethical issues related to science and technology or studies for this purpose have rarely been brought up in the educational setting (Choi and Cho, 2001).

During recent years, there have been a number of propositions in favor of extending the role of museums in society, taking an active role to contribute in educating the public with scientific literacy (Henriksen and Frøland, 2000). A recent report issued by the Norwegian Ministry of Cultural Affairs(1996), states that museums should function as dialogue institutions and meeting places and be the arenas for public debate. Similar aims are outlined for museums in other countries, such as Sweden(Swedish Ministry of Cultural Affairs, 1994).

Therefore, this study examined the current event and activities of four internationally acknowledged museums in terms of their role in educating the public with ethical issues related to science development. The selected museums were the Science Museum in London, La Cité des Science et de l'Industrie in Paris, the Museum of Science in Boston, and the Deutsches museum in München, and they were visited by the researchers, who analyzed the collected information. Further information was collected via websites and related articles on the museums.

The results indicated that selected museums present ethical issues related to the development of science and technology, mainly on biotechnology and environmental problems. The type of presentations dealing with the ethical issues most frequently were exhibitions, panels and simulations, followed by demonstrations and lectures. All of the selected museums had common characteristics for actively taking the educational role in ethical issues in science. The programs were age-appropriate for the public, threw questions to stimulate thought and self-inquiry. The themes and topics on ethical issues were constantly updated in order to catch up with the developmental pace of science and technology (Song, *et al.*, 2002).

Along with what has been explained from this study, further suggestions can be made to develop more efficient educational materials and approaches for the museums. Firstly, hands-on activities would be efficient for learning ethical issues since they are otherwise rather abstract. Many of the ethical concepts deal with predictions and probabilities pertaining to the science and technology development outcomes, it is not easy to comprehend the concepts. The activities involving manipulations of objects to examine the changes along with their own input, such as pushing buttons, throwing objects, etc. is a concrete presentation of consequences. In order to make an experience concrete, active participation and experiencing manipulation would be a meaningful learning experience. For example, in the science museum in Paris (La Cité des Science et de l'Industrie), there was a unique activity on ethical issues in human equality and environment. When explaining the issues of unequal distribution of energy and environment problem derived from it, with a push of a button, the line shows the procedural steps showing how energy is generated and distributed. In the process, it shows how the energy leaves out some of the houses and sent only to a specific area, unevenly distributed. Such concrete manifestation of energy distribution would reinforce the grasping of concepts (Wellington, 1990).

Secondly, the activities should involve a multi-sensory approach. It would be helpful to utilize materials and aids with multi-sensory approaches. Many of the programs provided in the selected museums have employed visual aids in communicating the theme. However, including

auditory, visual and tactile aids and materials may be more efficient in learning. Such multi-sensory exposure would play an important role in comprehension and understanding of the ethical issues and concerns.

Third, among many types of technology, the museums presented ethical concerns mostly related to biotechnology and environmental issues. In terms of other types of technology, such as nanotechnology, they were discussed to the extent of what it was about, however, they did not deal with ethical concerns related to these as frequently as others. Therefore, it is important that museums expand in presenting ethical issues on other types of technology besides the biotechnology and environmental problems. As mentioned earlier, it is the museums' role to be the informant of the news for findings in science and technology including the facts, exploration and inquiries on ethical issues.

The advancement and rapid proliferation of science and technology in almost every aspect of human activity has given rise to a host of associated ethical and moral issues. Particularly, environmental crises, such as pollution, the depletion of resources, and the threat of war have been cultivated to a large extent as a result of development and application of science and technology. Ethical problems have become an urgent matter-of-fact problem of modern society as science and technology develop rapidly. The need of education on ethical issues is being emphasized more than ever. People need an understanding of science to relate to the many complex science-related issues that confront citizens of modern democracies (Henriksen and Frøland, 2000).

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