

# Learning about Junk Science

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by

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On my honor as a University student, on this assignment I have neither given nor received unauthorized aid as defined by the Honor Guidelines for Papers in Humanities Courses.

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“To preserve our four-hundred-year commitment to a scientific worldview, we need our educated people to incorporate scientific thinking- the blend of curiosity and skepticism, the habit of critical questioning- into their very nature. Pioneering new teaching styles in science and math, carried out in cooperation with the liberal arts, can help achieve that”<sup>1</sup>

Leon Lederman  
*Skeptical Inquirer*

## **Abstract**

Society puts a lot of faith in technology and theories presented by scientific research. Unfortunately many scientific claims being made today are not based on sound scientific principles. They are a result of junk science. Some motivation factors behind junk science are the media, political influences, legal and social issues, economic pursuits, the experimental procedure itself, peer review, and the lack of science education of the public. One reason why the public so readily accepts information based on insubstantial scientific principles is due to the major decline of our science educational programs. The objective of my thesis project was to create a web page for use as a teaching tool for high school science classes. Through the process of researching and investigation existing cases dealing with junk science, the goal is to promote thought and encourage students to question scientific claims and theories. As educated and conscientious citizens equipped with the ability to process relevant information, we as a public will be able to better process scientific information and be less tolerant of junk science and its implications on society.

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## I. Introduction

"Extensive scientific testing has shown that proper use of food irradiation does not present a health hazard. All of the evidence indicates that consumers have nothing to fear from irradiated foods but instead can look forward to a greater variety of high-quality food products if this process comes into more widespread use in the United States."<sup>2</sup>

Kathleen A. Meister, "Irradiated Foods",  
American Council on Science and Health, 1985

"My contention is and has been that a dose of radiation sufficient to cause changes in food pathogens to result in their death must cause comparable changes in the food itself... The actual dose of radiation is irrelevant since a single carcinogenic insult is all that is needed to produce a malignant neoplasm a decade or more later. Thus, irradiated food should be safe only for individuals with a life expectancy of a decade or less..."<sup>3</sup>

George L. Tritsch, Roswell Park, Memorial Institute,  
letter to Chemical and Engineering News, July 21, 1986

Which one of these is true? It is possible that one of these is completely wrong and based on inaccurate scientific data. It is also possible that the scientific research behind each recommendation is valid. If the latter is true, how is it possible for scientists to look at undistorted scientific data and come to different conclusions? This suggests that the information may be ambiguous and open to interpretation. Although this is generally true about scientific research, we often regard science as a cut and dry process that yields answers and provides solutions to our problems. We often view scientists as providers of complicated, intricate information that only they can decipher and make recommendations from. Therefore we entrust scientists to provide us with answers and place our faith in their guidance. With this growing lack of awareness, we become susceptible to misinformation and fall prey to the fallacies of junk science. This precise issue of junk science is the topic of my paper.

## **II. What is Junk Science?**

According to Steve Milloy, the executive director of The Advancement of Sound Science Coalition (TASSC), " 'Junk science' is bad science used by lawsuit-happy trial lawyers, the 'food police,' environmental Chicken Littles, power-drunk regulators, and unethical-to-dishonest scientists to fuel specious lawsuits, wacky social and political agendas, and the quest for personal fame and fortune." <sup>4</sup> It is a term that can be used to describe many circumstances and situations. It can also be manifested in many different forms. Our discussion will be limited to the following three considerations.

- A. Situations where the interpretation of the scientific data and the recommendation made from it are influenced by external factors.
- B. Intentional fraud and other instances where scientists obtain their data in a questionable manner.
- C. Common misconceptions of basic scientific principles.

### **A. Interpretation**

In her discussion of this issue, Beth Savan states "Scientific investigation is not a straightforward act of observation and recording, but rather a complex series of personal choices and subjective interpretations."(Savan 1988, p.21). The previous discussion of the health effects of food irradiation is an example where a discrepancy in the interpretation of scientific information can exist. Both recommendations, even if they were based on sound scientific data, cannot be true. While the purpose behind scientific research is to pursue "truth", not all scientific research is conducted under that mentality. Some scientists may conduct research to support a certain existing theory or to communicate the significance of a project to a potential investor. The motivation behind their research may be a contributing factor in the interpretation of the collected data. Karl Popper, a prominent figure in the struggle between "good" and "bad" science believed strongly in an approach to experimentation that set out to *falsify* rather than prove a theory. He felt that this approach would help in avoiding such confirmation bias.<sup>5</sup>

Scientists are often expected to act as data processors- flawlessly objective. We forget that they are humans and are susceptible to having biases that may effect their work. And given the uncertainty and ambiguity of most scientific data, such dispositions can be a major contributing factor in establishing the validity of the data and the conclusions drawn from it.

Other biases, such as preconceived notions, philosophical, religious or ideological beliefs, can also influence a scientist's research. Some common cases involving such dispositions are alternative medicine, New Age philosophies, and creation science. One famous case illustrating the disastrous effects of ideological and political pressures on science is the one involving Trofim Lysenko. Lysenko, a Soviet biologist and agronomist,

refuted Mendelian genetics and claimed that the genetics of plant characteristics could be easily manipulated to serve a desired purpose. This process, known as "veneralization" promised to revolutionize Soviet agriculture. His theories, despite many challenges and questioning from the worldwide scientific community, received support from Stalin and the Soviet government. Thousands of researchers who questioned his theories were dismissed from their jobs, imprisoned, and even killed. The Soviet government mandated the implementation of Lysenko's plan on a large scale degree and what resulted was "... an unprecedented, manmade agricultural disaster causing untold human suffering and environmental damage that continues to plague Russia today."<sup>6</sup>

## **B. False Data**

This case is not only an example of junk science, but could possibly be classified as a case of fraud. Although he received the support of the government, it is unknown whether or not Lysenko knowingly supported false data or actually believed his theories. Some scientists purposely skew their data or conduct research without following proper scientific method. Some scientists may feel it *unnecessary* to follow the appropriate methods. They may consider themselves to be very knowledgeable about the subject matter and make conclusions without actually carrying out the procedures. They may see it as a waste of resources, and claim to have observed experimental results which in actuality were thought experiments. Other contributing factors which may cause scientists to use illegitimate data may be due to the lack of resources such as time or equipment. A student performing an experiment may be approaching deadlines and make modifications in the testing procedures or manufacture convincing data in order to meet his deadline.

Alterations may be necessary to finish the experiment with the available resources. Such changes might inadvertently introduce significant errors into the experiment.

Surprisingly, a great number of cases involving fraud or the possibility of fraud have occurred throughout history and may still exist today. One example occurred at the University of Toronto in the late 1970's. Demetrios Spandidos, a post-doctoral fellow came highly recommended to work for Dr. Louis Siminovitch, a well known and respected researcher. In 1977, Spandidos reported that he had discovered a method of transferring genes from one strain of animal cells to another. This was a great discovery which promised many possible applications. Spandidos continued to do great work and within a year and a half, was able to co-author six papers with Siminovitch. He also went on to receive the distinguished Centennial Fellowship from the Canadian Medical Research Council. In 1978, another researcher Bill Lewis also working with Dr. Siminovitch found many inconsistencies when he tried to replicate Spandidos' experiments. Questions as to how he obtained his results began to arise. Although he never admitted any wrongdoing, investigations showed that Spandidos had not actually performed all his experiments. Further investigation showed that the ones he performed were done very carelessly. When questioned, he wasn't able to explain his own procedures or findings. He soon lost his fellowship and was forced to leave Canada.<sup>7</sup>

### **C. Common Misconceptions**

Another example of junk science is when common scientific principles are misrepresented or miscommunicated. This may occur for example in a classroom setting where an educator may fail to present students with relevant background information and

lead them to believe things which are not true. I once attended a 5<sup>th</sup> grade science class where the teacher told the students that Albert Einstein was the inventor of the Atomic Bomb. A more accurate description would have been to state that he was the scientist accredited to the discovery of the scientific principles, which others later used to develop the bomb.

### **III. Motivating Factors**

There are many motivating factors behind junk science. Some have already been mentioned in the above discussion. We will be focusing on seven potential causes which encourage the development of junk science. These are the media, political influences, legal and social issues, economic pursuits, the experimental procedure itself, peer review, and the lack of science education of the public.

#### **A. The Media**

According to Steve Milloy, an authority on the subject, the mass media is one major proponent of junk science. He feels that most scientific information found in headlines is junk science. This is due to many reasons. The media wants to report clear concise statements which hold the attention of the public and tell them what to avoid or pursue. As discussed earlier, science is a very intricate and involved *process* which rarely yields single statements of truth. Reports commonly start out “ A recent study shows that ...”. It is virtually impossible for *one* study to prove or show anything. Although this approach is used often when reporting medical information, years of research have to first

be conducted before a definite relationship can be established- if it is at all possible. This also stands for the causation relationship which is commonly found in headlines. A report may read "...causes ... in...". This is usually an indication that the information cited is questionable. There are many factors which influence causation. One question that should be asked is if a control group was used in the study. The conclusion may also be based on causation by association, which is very misleading, as opposed to causation by evidence of epidemiological studies- which is a much more reliable method.

The Advancement of Sound Science Coalition recently commissioned a study on the way news media has treated scientific evidence specifically in covering the public health effects of calcium channel blockers and silicone breast implants. The analysis of 143 reports indicated that many headlines were misleading, the meaning and limitations of the studies were not sufficiently explained and the reports generally did not serve as a good basis for making informed conclusions.<sup>8</sup> The full report as well as methods of analysis and other details can be found at

[http://www.tassc.org/html/latest\\_activities/study.html](http://www.tassc.org/html/latest_activities/study.html)

## **B. Political Influences**

It was political influences and regulatory efforts that forced General Dynamics engineer Stacy Walbridge to stop working on his project. He was involved in the building of atlas and centaur rockets. At the time, freon was being used to measure the internal

tank pressures of the rockets. In 1987, the Montreal Protocol took effect and started the gradual phasing out of CFC's (which includes freon). After doing independent research, Mr. Walbridge was unable to find substantial evidence which supported the claim that exposure to freon was a health hazard. When asked what he thought was the cause of such junk science, he responded by saying "If you let science take its natural course, it will eventually prove itself. It's when it's picked up by regulatory or political process that it becomes junk"<sup>9</sup>

Policy makers and politicians alike look to science to provide them with a specific answer. All they want to know is whether or not it's dangerous and needs attention. Unfortunately, the complex nature of science does not allow for that type of recommendation. This problem combined with the distorting tendencies of the media reporting "urgent dangers" to the public, places the policy makers in a difficult situation. They lack the expertise to decipher the scientific data but want to make decisions which promote the welfare of the public and/or pursue their personal political interests.<sup>10</sup> Unfortunately, the real scientific evidence gets lost in the process and as a result "...makes governmental actions hostage to misinformation...[and]...needlessly costs taxpayers and consumers billions of dollars a year."<sup>11</sup> Many people feel this is the case with the concern over global warming while others feel government action is necessary to safeguard against the *potential* hazard.

### **C. Legal and Social Issues**

The same problem exists in the handling of scientific information in the courts. Science cannot provide clear answers or identify causes of disease to resolve questions which are the focus of much litigation. “Thus, important social issues must often be decided on the basis of uncertain scientific evidence.”<sup>12</sup> A great example of this is the highly publicized silicone breast implant controversy. Despite the fact that scientific studies are still being conducted to determine if a link exists between implants and disease, courts have passed judgments concerning the very same question and have settled hundreds of thousands of cases around the country. Is the legal system more expedient in establishing the truth? Definitely not. Although both institutions are in search of the same “truth”, underlying differences between the scientific method and the legal process, and lack of tolerance of each for the other is what presents the greatest problem. From previous discussions we have seen that scientific evidence is usually uncertain, takes a long amount of time to produce, and many times cannot support a “cause” or “effect” deduction. On the contrary, the legal process aims to come to a yes/no, guilty/not-guilty verdict using *presented* information within a limited amount of time. One cannot wait or ask for better evidence in order to make a decision.<sup>13</sup> Because the legal system fails to understand the real contribution and implications of science, they often allow faulty judgments to be made based on incorrect assumptions and inferences of scientific evidence.

#### **D. Economic Pursuits**

Money motivates the perpetuity of junk science. We can see from the breast implant controversy that it was the difference between the legal process and the scientific process and the interpretation thereof which lawyers were able to capitalize on. It wasn't until two months after the \$4.25 billion class action settlement was negotiated that the first reliable epidemiological study was conducted.<sup>14</sup> In other words, they could interpret the data and shape it to make a judgment based partially on scientific evidence before even the first epidemiological test was conducted.

Manipulation of scientific data for the purpose of economic gain is also commonly found in corporate practices. In 1977 an investigation of a private U.S. laboratory called Industrial Biotest Laboratories found them to be guilty of manipulating as well as fabricating false scientific data in order to prove the safety of chemicals for pesticide manufacturers. The company compromised scientific research as well as the health of people who would be exposed to the chemicals for the pursuit of receiving more business from the manufacturers.<sup>15</sup> In more recent cases for example ,Goodrich Tire Company<sup>16</sup> purposely skewed their data to indicate their airbreaks as being superior in order to win a bid from a company. This further illustrates the influence of economically based pressures on scientific research. The self-imposed pressures of academia, such as finding funding for a project or seeking recognition in a specific field, may also influence professors and researchers to contribute to junk science.

## **E. The Experimental Method**

“Assessing the reliability of scientific testimony thus requires a two-dimensional measurement. One aspect involves the reliability of the observational tools and the skills of the observer. The other looks beyond the observer- possibly (though not necessarily) to methods accepted by other observers in the same field, and certainly to established scientific knowledge in the field.”<sup>17</sup>

This quote discusses the importance of the experimental method and specifically, factors such as assumptions made, error incurred, and the importance of peer review.

Some assumptions may need to be made in science experiments. In order to avoid introducing error into an experiment, a researcher may assume for example that a particular sample of mice were fed the same food and raised in the same habitat. If these assumptions were indeed false, it may introduce a significant amount of error in the results depending on the type of research being conducted. In the early 1980's, it was discovered that Charles River Breeding Labs Inc. was falsely supplying researchers with the “wrong” type of mice. Inbred special stock mice were believed to be one of the single most important tools for the success of experiments in cancer research. Almost a thousand scientists had conducted experiments based on the assumption that the mice were of this type before they discovered the truth.<sup>18</sup>

This factor introduced an unanticipated source of error in the experiments. Many believe scientist underestimate their errors and overestimate the reliability of their research. The best way to gauge such error is to compare it to error calculation methods of other experiments done in the same field.<sup>19</sup>

It is also important to keep in mind that results from two different experiments cannot be fairly compared unless they were both conducted in the exact same manner. In the development of sound science, it is also important to look for common accepted experimental methods used in that field of research. Analysis of the experimental method

and peer review of research are two things which can contribute to the elimination of junk science.

### Lack of Peer Review

After conducting research and reaching a conclusion, the scientist should then present the information to their peers for review. Marcia Angell stresses the importance of “peer review” in the following quote. “...the most honest researchers cannot be expected to judge their own work dispassionately. They are likely to be enthusiastic about their ideas and, almost by definition, not aware of flaws in the design of their study and interpretation of their data.”<sup>20</sup> In highly controversial cases and exciting breakthroughs, researchers may skip this step and present the information directly to the media.

This was the particular case of Pons and Fleischmann and their alleged discovery of cold fusion. Stephen Jones, who started doing research on cold fusion after reading their work became their rival in the pursuit of unfolding the cold fusion phenomenon. As Jones made advancements and presented reports, Pons and Fleischmann feared that he would be recognized as the primary discoverer. In order to beat him to the punch, they bypassed the very important step of publishing their findings in a refereed journal, and announced their discovery at a press conference. Scientists around the world then attempted to replicate their experiment and found many inconsistencies. This brought on much criticism and more importantly questioned the scientists’ credibility.<sup>21</sup>

While the peer review process may stop papers with highly questionable data , it is not a foolproof method of identifying junk science. The eloquently written reports which “hide” the inconsistencies may slip through. In such cases, the reader may not have access to the actual data nor may they have time to investigate the issue.<sup>22</sup> Although an essential step in the experimental procedure, the process of peer review should be used with regard to its limitations.

#### **F. The Public’s Lack of Scientific Knowledge**

Another major factor which advocates junk science is the public’s lack of scientific knowledge. The general public is incapable of processing and analyzing scientific information. According to an article in the Skeptical Inquirer, 93.8% of the U.S. public is scientifically “illiterate”. The criteria used to define “illiterate” was not defined although with the vastly growing wealth of scientific information and increasing levels of complexity, society seems to be leaning to a more “dogmatic” way of thinking. This is a way of thinking where decisions are based on authority rather than logic and evidence.<sup>23</sup> The silicone breast implant controversy is one example which illustrates this. As soon as the public heard news which questioned their safety, instead of asking questions and searching for proof, the main concern became figuring out who to blame.<sup>24</sup>

We must ask ourselves why would one of the most developed countries in the world have a public that is so disinterested, and ignorant about scientific issues? The saying “ignorance is bliss” applies; because it is simply easier. It is much simpler to ignore

something complex and intimidating rather than to take the time and effort to confront it- especially if one does not have the resources to do so.<sup>25</sup>

One main reason for this is the poor quality of science education in the school systems. An international study of educational performance rated American students average in areas of math and science.<sup>26</sup> Recent statistics from the National Assessment of Educational Progress show that only 26% of fourth and eighth graders and 18% of high school seniors were proficient in science. The statistics worsen with black and hispanic students out of which 77% and 67% respectively scored below the "basic" level.<sup>27</sup>

Without even basic knowledge of science and how it works, how can students understand and interpret scientifically based information and judge its validity? They simply cannot.

President Clinton is currently developing plans to toughen standards in basic science education. But students do not only need to learn the basic principles of science but they also need to be trained to process and analyze the scientific information they receive.

Without the ability to think critically and independently, students -thereby the general public, is susceptible to misinformation and fall prey to the fallacies of junk science.

#### **IV. What can be done?**

The answer lies in education. Many organizations such as The Advancement of Sound Science Coalition, publications such as *The Skeptical Inquirer*, medical journals, TV news and educational programs, and other various independent efforts on the web are trying to educate the public against scientific misinformation. With the help of such sources and programs, the public needs to learn how to appropriately process scientific

information. We must learn to question and demand scientific evidence behind proposed claims so that we can make well informed decisions.<sup>28</sup>

### How do we learn to question the validity of scientific information?

Throughout our elementary and secondary school training, we have been conditioned to accept most of the information we have been taught as factual. In regards to science, whether it be Einstein's theory of relativity or the speed of light, we often forget that much of the information presented to us are merely theories. A theory is defined as "a supposition or system of ideas explaining something." A hypothesis which has not yet been disproven. In science classes today, there is not enough emphasis on the value of testing hypothesis and challenging theories. The problems which exist in current science curriculums are expressed in the following quote:

"Educators have argued convincingly for greater emphasis high-order thinking skills and for integration of hands-on and laboratory projects in the classroom. Yet current practice tends to emphasize results rather than processes, to rely heavily on memorization of facts rather than the understanding of concepts..."<sup>29</sup>

Hackerman, in an article about science illiteracy, also discusses the importance of critical thinking in science. He states that "They [students] don't need to know how to split the atom. Or how photosynthesis works. What they do need is sufficient science literacy to function effectively in today's technical world."<sup>30</sup>

## **V. Objectives**

In light of all this information; the great significance of science in our lives, the public's general lack of scientific knowledge, and the ramifications of inaccurate scientific information, my objective is to attack this problem by training young students to recognize the problem. A learning program instituted in schools across the country, it would help lead to a future of a scientifically well informed public. If more people can identify ignorance to scientific information as a problem in society today, they will become aware of their own misconceptions and make an effort to become well informed. A bug sitting on your shoulder doesn't bother you until you recognize that it's there.

In order to accomplish this feat, I am designing a teaching mechanism to be used in high school science classes to educate students about junk science. Its purpose is to inform students about the existence of junk science, to encourage them to question scientific claims and theories, to stress the importance of and aid the development of their analytical skills, to encourage them to research and seek information for themselves, and to bring science to life by showing actual examples of how science takes place in our daily lives.

## **VI. Design of Web Page**

### **A. WWW as a Teaching Medium**

Considering the objectives outlined above, the next step was to determine the best way to provide this information to the students. As stated above, some educational programs on TV, sources on the world wide web, journal articles, and a few number of

books are currently the only defense students as well as the public has against science misinformation. Because of the nature of this project and resources available to me, I did not see the television, journals, or books as appropriate mediums for providing this information. These are also very difficult tools to use in a classroom setting. Instructors would have to first become knowledgeable about the topic and present the information in a lecture format. For this and many other reasons, I decided that the world wide web was the best teaching medium to use. The presentation style, the level of interaction, and access it provides to more information make it an ideal environment for teaching about junk science.

David Brooks in his book entitled *Web Teaching* expresses some of the other advantages of using the web as a teaching medium. “The Web’s greatest intrinsic power is that it encourages branched, nonlinear instruction. Not only can students jump around among the materials that you have created for them, they also can access materials created by others.”<sup>31</sup> It is the one interface where an individual can access the greatest amount of information. The Family and Consumer Sciences educators use the internet to provide instruction because it enables the students to keep up-to-date with various types of information.<sup>32</sup> Many also believe that the web is a good place to conduct high-level and hard-to-find research. Some schools are presently using the web to conduct this type of research through the Department of Trade and Industry’s project called Schools OnLine.<sup>33</sup>

Using the web for instruction also encourages active learning. These are learning environments which require the student to respond, make choices, think deeply about the material, and take a role in the learning process. Active learning often shows to be more effective than passive learning where the student just listens to a teacher lecture.<sup>34</sup>

This gives students some control and makes the learning experience more enjoyable. They control the amount of information they collect and learning becomes voluntary. They also have the opportunity to be creative, as they carve out their own paths in their search of information.

Using the web as a teaching medium provides students with exposure to an alternative mode of learning. It enables students to learn under many different situations and circumstances.<sup>35</sup> There is currently little variation when it comes to teaching science. Teachers also agree that there is an overreliance on the textbook and lecture method used in so many classrooms. Most grading systems are based on a student's ability to recall that information. Jenkins and Macdonald in their article about science education express that there is little incentive or opportunity, especially in science, for teachers to evaluate students' ability to think. Questions which call for more thought and reflection would allow the students to apply what they've learned as well as explore related topics and expand their scope of thinking.<sup>36</sup>

Another benefit of using the world wide web to teach about junk science is due to the large amount of junk that is published on the web. This knowledge alone will help students understand the problem and allow them to practice questioning the validity of information they receive.

There is currently very few web-based educational programs which teach students about junk science. The only source I found was a Bad Science page which deals with common misconceptions of scientific facts maintained by Alistair B. Fraser, a professor at Pennsylvania State University. Although the web page I have proposed to create will be

the first of its kind, web-based instruction is on the rise and many believe it will be the conventional method of teaching in the future.<sup>37</sup>

## **B. Case Based Instruction**

Junk science encompasses too much information to cover in a single project. At the same time, it is important to represent as wide a spectrum as possible to investigate the different motivating factors behind junk science. The best approach to deal with this issue was to use case based instruction. This would allow for the presentation of situations which students can dissect and analyze, and explore how the lessons learned from that process could be applied elsewhere. Studies in cognitive psychology also support this method of teaching.<sup>38</sup> Case-based reasoning also facilitates transfer to real-world applications.

## **C. Format and Organization**

The next step in the design of the web page was to decide on the best format to use. I wanted to use an approach which would encourage students to participate rather than just read the information provided on the screen. I felt the best way to accomplish this would be to present students with common cases and problems which would require research and analysis. Posing such questions would encourage them to investigate and seek for answers rather than to simply read about junk science; because they had to work for it themselves, this makes the lesson more valuable.

Another factor to be considered was the type and number of cases to be presented. I wanted to do as many cases as possible illustrating many different points. This would provide teachers with a wealth of cases to choose from. Unfortunately, due to time constraints, I had to limit the number to three exercises. I also limited the scope of definition of junk science to the three types discussed in the introduction.

- Situations where the interpretation of the scientific data and the recommendation made from it are influenced by external factors.
- Intentional fraud and other instances where scientists obtain their data in a questionable manner. (this is still being worked out)
- Common misconceptions of basic scientific principles.

The lesson is comprised of five basic sections. The introduction section defines the term junk science, explains the motivation behind the lesson, and gives general advice to consider during study.(see Appendix A) Another section provides students with several links which they may find useful or interesting. The meat of the web page is in the set of three exercises. Each exercise is set up differently and requires students to use a variety of skills. Such variety is designed to prevent students from getting used to a particular format and losing interest.

#### 1. Exercise #1

The first exercise explores the silicone breast implant controversy. This highly complicated case offers many interesting aspects. It has become a highly publicized social dilemma which is still being debated about today. These properties make it ideal for use in studying junk science and its many causes,

influences, and results. This case shows students the complexity level of the issue of junk science. It is often very difficult to prove something as junk science. This also is not the goal of this project. This case when deeply examined shows the vast social and economical effects which could result from a scientifically based argument.

The case is presented in a manner which allows students to understand both sides of the issue. I felt the best way to do this was to present each side to a different half of the class. When the class came together to discuss the issue, each group of students would realize that they did not have the complete picture. This will help them realize how one-sided points of view, commonly portrayed by the media and other sources, can be very misleading and sometimes dangerous. One group is presented with information which supported the argument that silicone breast implants cause disease. There was some discussion of medical information, reports from the FDA, and accounts from a number of victims. The other side presents the scientific information dealing with the use of silicone in the human body, and various studies which did not show any connection between the implants and disease.

Some common information was presented such as assessing the quality of medical information on the web as well as general information about the controversy. Each group was then presented with multiple links to other sites and their descriptions. After reading the material provided and doing further research, the two groups will conduct a class discussion. They will attempt to answer questions such as: who is right? Who is at fault? Do the implants cause disease?

Can this case be resolved by scientific evidence? Etc. After the discussion, students will be required to write an essay stating what they learned from the discussion. They can discuss how their biased exposure effected their thinking, why they think this is or is not an example of junk science, and preventive measures which could have been taken by the manufacturers as well as the doctors and women with the implants.

Students will benefit greatly from studying this case. Outside of the intended lesson, the exercise will teach them how to work in groups, how to formulate and present arguments, it will allow them to exercise their writing skills, and stress to them the importance of being able to process scientific information.

## 2. Exercise #2

The second exercise deals with common misconceptions. These are basic scientific facts or principles which have been misrepresented to the general public. Some examples include the iron content of spinach, the coriolis effect, the shape of rain drops, etc. After reading the provided material, for each subject, students will find at least one additional source which addresses the issue. This can come from a book, encyclopedias, the web, etc. Students will then relay what they have learned or may already have known, to at least 3 people- family members, students outside of your class, etc. to get their reactions. This is to give them a better understanding of how susceptible the public is to misinformation. Students will then be required to write a short paper (1-2 pages) on their reaction to the informal "survey" they conducted, what they think are the causes behind these common misconceptions and their general feeling about junk science.

Some benefits of this exercise are that it helps make science interesting. Most students will be surprised by the information they find out. They will hopefully also gain interest simply by discussing the issue with other people.

### 3. Exercise #3

The last exercise is designed to give the students some flexibility. They will select a topic of their choice for research. This is their opportunity to explore the topic and find out more interesting things. The topic chosen does not have to be one where the common perception is completely wrong, it can be a controversy or issue where science can be used to bring the issue to a more understandable level. Some suggestions such as global warming and second hand smoke are presented but students are encouraged to research topics of their own. They will then write a 3-4 page report defining their case, presenting the information they collected, and an analysis of the information. Students will then be required to give a 2-5min. informal presentation about their topic.

This exercise provides many benefits. Students will gain public speaking skills in presenting the information to the class. It also shows them how junk science is a part of our everyday lives, and allows them to be creative in their approach. This exercise also helps promote self regulated learning (SRL). SRL allows the student to adjust their interest, motivation, and performance levels to fit the demands of the exercise. This gives them enough freedom to set their own goals as well as limits.

## **VII. Discussion**

The main purpose of this project was to call attention to the issue of junk science. This goal was reached through a number of different media. Although not out of intent, by sheer involvement in the project, many people have been exposed to this matter and have found it to be very surprising and interesting. My technical advisor, library attendants who have helped me in my research, friends, family, and classmates effectively "participated" in the accomplishment of my goal.

The objective of my project was to construct a web page to be used for instruction in high school science classes. In pursuing this goal, I was required to do work with two different arenas, junk science and web-based science education. I investigated the topic of junk science by reading and talking to authorities on the topic. I was able to get a good understanding of what it was, why it exists, and how to approach it from an educational standpoint. I then researched using the web as an instruction tool and spoke to people in the education department.

The goals of the web page were to inform students about junk science, to encourage them to question scientific claims and theories, to stress the importance of and aid the development of their analytical skills, to encourage them to research and seek information for themselves, and to bring science to life by showing actual examples of how science takes place in our daily lives. Each of these was considered and factored into the design of the exercises. The purpose of each exercise and the benefits they offered were outlined in the previous section.

The real question now becomes, can this web page serve its purpose in real classrooms? Unfortunately, this was one of the things I was not able to test. In the

beginning of the project, I had planned to incorporate a testing phase where students would actually perform the exercises. As the project developed, the time commitment the exercises required, and time restrictions on my behalf did not allow for testing to occur. Instead, I asked my classmates, an authority on the topic, and a graduate student in science education to review the contents of the page and provide their feedback. I found this information very insightful. Most of my classmates as well as Steve Milloy of The Advancement of Sound Science Coalition liked the information presented and thought it would be very useful. (See Appendix B to view actual comments). Some general suggestions made were to put a comments link on every page, use Java enhancement for the images, and formulate an evaluation form to be placed as a link. I held a meeting with Leo Racich, a graduate student in the Center for Science, Mathematics, and Engineering Education, and received a lot of information which will greatly effect this project. The following are minor suggestions broken down according to sections.

### Title Page

- put descriptors on all images for people who turn images off
- find a better picture of a plant- current one resembles a crystal
- use the opportunity to be creative with the word “junk”

### Introduction

- increase the size of text
- as a courtesy to authors, use more noticeable colors for links
- on each link, better indicate the source to give credit
- give a better definition of junk science
- provide date of junk science program on ABC

### Exercise #1

- timeline- use the word “first” instead of 1<sup>st</sup>
- write out first mention of abbreviations – JAMA

### Exercise #2

- motivate students by encouraging them to submit ideas for posting
- possible topic- survey of Harvard graduates on the seasons

### Exercise #3

- provide one source for possible topics
- possible additions- aromatherapy & laetrile

There were also other concerns Mr. Racich raised which will have to be considered and addressed. In the introduction section where junk science is defined, a discussion of scientists who make recommendations outside of their field of expertise contribute to junk science and should be mentioned. Also, in the discussion of the motivation for the project, the word “theory” needs to be better defined to indicate that theories can and should always be challenged.

In the discussion of breast implants, Mr. Racich suggested keeping the opposing views separate and putting the general information as a separate link. He also suggested that students be assigned to argue one side of the issue but be allowed to view the information on the opposing side. He made the good point that no lawyer goes to argue a case without looking into the other side.

One piece of information relayed by Mr. Racich which could affect the scope of the project is the use of the world wide web in current high schools. Presently, many schools who use the web as a teaching guide get permission from the source and copy the cites onto a main computer from which students can access preloaded files. In effect students will not be “connected” to the web and will not be able to perform many of the exercises presented. Given the many links and sources of information cited on the pages, it would

be unrealistic to get permission and save each link as an independent file. At the same time, some links may become inactive over time and may need to be copied.

For schools who have active access to the web, there was also the concern of web nannies which monitor the sites students can access. In this case, due to the keyword “breast” in the silicone implant case, it may not let students access the site.

All these concerns indicate that high schools science classes may not be the optimum place to implement the site. Community colleges and introductory level college courses may benefit from the information the best. This was also the opinion of a classmate. Currently, I am in the process of carrying out the changes and determining where I would like to see this project go. It is possible that after the changes have been made, the site may be transferred to the education school for actual testing and implementation.

With the future implementation of such a learning program, students will be conditioned to question the validity of cases presented and the theories behind them. This will encourage them to research the topics and experiment on their own. The investigation of certain scientific principles will encourage students to be innovative thinkers. With more encouragement to *participate* in science rather than observe, more students may come to view it as a possible career choice. This may also result in the increased involvement of female and minorities in the field of science and engineering.

As students become aware of junk science and its impact on society, they will gain a reinforced understanding of the value of ethical principles in the work place. This will lead to a future of responsible scientists, teachers, legislators, engineers and journalists

who know the importance of presenting the public with legitimate information found on sound scientific principles.

As educated and conscientious citizens equipped with the ability to process relevant information, we will be able to better process scientific information and be less tolerant of junk science and its implications on society.

"Honest education may generate, will generate, as many critics as admirers of science. This is the kind of criticism that science needs to keep it sharp. Ethical and social responsibility at the highest level is essential to our future." Leon Ledermanf *Skeptical Inquirer*

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