Science and Ethics: Implications for Teacher Education

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Abstract

*The discipline of Science has generally been viewed as absolute and value-free. 20th century has seen sciences endowed with materialist and technological bent of researches. Technology as a fruit of it seems to have abstracted itself completely from the society at large. This has been a direct result of the positivist character of science that completely neglects the naturalistic order. Scientists and technologists have never been concerned with the ethical or moral questions that arise in the society. But it has now been agreed rather proved that science and technology without ethics cannot be liberating in a true sense and since then there has been a constant urge to include this component in science education. One suggested way of integrating the ethical component into science is the integration of socio-scientific issues** in the science curriculum with a sound grounding in ethics. The present paper attempts to elaborate upon two such contentious issues: genetically modified crops and animal experimentation, along with the socio-ethical debates centered on them. The purpose of the present paper is to highlight the areas of confluence between science and ethics, portray their significance in science education as well as to show the need for pedagogical improvement and innovation with regard to dealing with these issues in the classroom.*

Introduction

Sciences have always enjoyed an elite status in our society, owing to their liberating potential, in terms of getting our society rid of the superstitions, dogmatic beliefs, certain theological and theosophical firmaments, in a way having a major contribution in our evolution. Although this status has been acquired after very many conflicts

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** Socio-scientific issues (SSI) refer to the issues at the interface of science, technology, and society, such as global warming, amniocentesis, euthanasia, etc., along with the consideration of ethical issues and construction of moral judgments about scientific topics via social interaction and discourse (Zeidler, *et al*, 2004) . They are controversial in the sense that they are being understood and viewed differently by different people, and thus share multiple perspectives.

and criticisms, which was for the first time triggered when Copernican theory of Heliocentrism replaced the Geocentric theory propounded by the church. This marked the beginning of the scientific revolution that was one of the contributing factors in eradicating the idiosyncrasy in society and its people.

The advances in science and technology have always been regarded as progressive steps toward the development of society. However this notion has now been getting dialectically viewed owing to recent science and technology disasters, not requiring a great mention is Japan's Nuclear Reactor peril and simultaneous hazardous radiation effect on the masses, which as is a well known fact, will be carried over to the generations to come. All of this and many more such incidents, compel us to think whether the trajectory of development or more precisely the researches in science and technology are heading in the right direction? Do we require taking a detour and placing the humane component at the centre of each and every scientific research?

A scientist is considered as good and his/her contribution or discovery sane only when he/she is also philosophizing on the chosen area of research. Beneficial researches are those which do not pose any harm to the society, as an immediate outcome and even in the long run. This requires sound decision making on the part of scientists and researchers, who are actively involved in the process. The people practicing science as well as part of some scientific researches is the only ones who are well informed about the pros and cons of their respective researches and their overall impact on the society. Hence, their role becomes pertinent in deciding whether a particular research should be taken up or not. Here comes the question of ***"ethics"***, which can be defined as the inherent value-process, thought structure, including norms and conduct of a society.

Ethics in Science

Ethics and science have usually been regarded as dichotomous and disjoint by many philosophers and scientists. The arguments given in favour of this is the difference in the nature of the two disciplines, of which Ethics delves into the analysis of moral values, justification of certain norms in the society and universal rules of conduct such as honesty, integrity, benevolence, cooperation, etc., whereas sciences historically have been treated as objective and positivist, and have generally adopted observation and experimentation as the chief modes of enquiry. However, now that we know all those principles and values dictated by ethics play pertinent role in determining the authenticity of a particular research. A scientist also needs to observe these ethical values such as doing the experiment with honesty i.e., correctly recording the data, does not plagiarize it, cooperate with fellow researchers and scientists, should not hide the results of his /her experiment, etc.

The first to exhibit the ethics of science was the great American sociologist Robert K. Merton (1973), who founded the scientific sociology of science. He stated in a landmark paper on science and the social order, published in 1938, that science has an

ethos that consists of intellectual honesty, integrity, epistemic communism, organised skepticism, disinterestedness, impersonality, and universality (Richards, 1983).

Ethical Issues in Biological Sciences

The knowledge and application of the ethical principles become even more important whenever there is a question about one's survival, choices between alternative lines of treatment, whether to do experiments on animals and humans, decision-making regarding patenting of human genes and human genome project, using cloning vectors and producing recombinant organisms, etc. All the aforementioned techniques make use of some scientific principles to give rise to a new technology that can be used for the betterment as well as detriment of human race and thus require appropriate decision making. Since there could be many choices available vis-à-vis utilization of a particular technology, hence they come under the ambit of ethical issues and should thus follow ethical model of enquiry. Some of the philosophers of Science even regard sciences as pure, unintentional and means driven but technology as determined by societal demands and hence ends driven. Here it is important to understand the relationship between science and technology that are often used synonymously in scientific literature. Mario Bunge makes the distinction clear by stating it as

"Science is always innocent, whereas technology can be guilty. The reason for this difference is that basic science is the search for truths about reality, whereas technology is the search for efficiency through the design of artifacts. Thus, whereas for science truth is both means and goal, it is only a means for technology (Kurtz, 2007)."

Bioethics has emerged out to be as a separate branch dealing with issues such as donation of organs, tissues and cells, including gametes, research in embryology, participation of humans in experimental research projects and treatments, diagnostic and therapeutic use of genetics, introduction of genetically modified organisms (GMOs) in agriculture, etc (UNESCO, 2001).

Ethical Decision Making

Such contentious issues can only be solved by way of ethical enquiry, so as to arrive at favorable solutions. There are mainly two schools of thought with regard to the application and method of ethics – the first and most prevalent method of ethical enquiry is **"Deontological"** which means laying more stress over the rules and intentions behind a particular action without bothering about the result or outcome of the act itself. The second school of thought is the **"Utilitarian"** that gives more importance to the consequence of a particular act and more so with the principle of beneficence that is maximum benefit to the majority of people (Minkoff and Baker, 2004).

Our concern here is to apply these methods of ethical enquiry to address and solve the controversial issues related to science and technology. This has led to the emergence of a separate branch termed as *applied ethics (Frey and Wellman, 2003)* , that goes beyond

theory and step into real world ethical practice, such as questions of whether or not sex-determination is correct, which is just one case where ethics plays a pivotal role or has the privilege of application.

These methods of ethical enquiry help in making value judgments and sound decisions regarding many science and technology issues having societal impact (collectively referred to as Socio-Scientific Issues). Thus, a training with respect to the ethical decision making needs to be given to the people practicing sciences, whether they be scientists, researchers, science teachers or students. At the level of school and college education this would mean ethics to be ingrained in the science curriculum not to say it in the form of a separate subject or course rather intertwined with the regular teaching learning, so that they form an implicit part of science subject content knowledge.

In order to support the above laid argument about the interlink ages between science and ethics the present paper has the following as the *primary objectives*:

1. To study and understand the relationship between science and ethics, with special reference to two case studies.
2. To study the researches in the area of "ethics in science and education" from the period 2000-2010.

In order to cater to the first objective of this study, two ethical issues are being chosen viz., Genetically Modified (GM) Crops and Animal Experimentation. These issues come under the ambit of socio-scientific issues (SSI) and have generated a volley of arguments both within the scientific community as well as outside it. The idea behind bringing these issues here is to articulate and congregate the conflicting arguments and address the ethical dilemma which arises after going through them.

About GM

For understanding the ethical issues and major debates around GM Crops, it is important to understand the terminologies. GM crops, as the name indicates are the genetically modified crops, involving the insertion, deletion or silencing of genes to give rise to a new organism with modified characteristics. These modified traits in plants can include pest resistance, enhanced water retention capacity, better yield, increased shelf-life, added nutrient value, etc.

Major Debates Centered Around GM Crops

Arguments in Favour of GM Crops

The major objective behind the introduction of GM Technology in India particularly, has been multifold, including the concerns of hunger, poverty, and economic trade off. These have been discussed in the following manner:

Issue of Hunger

On the Global Hunger Index 2008 (Grebmer et al. 2008) India ranks only slightly above Bangladesh, and below several Sub-Saharan African states, such as Cameroon, Kenya, Nigeria and Sudan. The conventional agricultural methods of crop production do not offer much promise in eradicating the

problem. The Government of India (GoI) strongly feels that for India, Agbiotechnology is a powerful enabling technology that can revolutionise agriculture (DBT 2007).

Issue of Poverty

GM technology offers an incentive to the poor farmers, by increasing the crop yield, offering climate resilience, as well as profit making, thus annihilate their agony and dependence on infrequent climate changes and extra funds to raise the crop. The cost of production also reduces on account of lesser need for pesticides in GM crops.

The numbers of applications of pesticides in non-Bt. crop were 19.8 as against 6.6 in Bt. cotton. The cost of pesticide use per hectare came to $ 726 and $ 136 for non-Bt and Bt. cotton, respectively.[1]

Issue of Acreage and habitat generation

It is now a well known fact that GM crops require lesser land area as compared to the non-GM crops, which saves the rest of the area for forestry and habitat for the wilderly. Norman Bortang, associated with the Green Revolution, has also postulated that the new technology — biotechnology — should be allowed to advance in the welfare of human race so that the vast stretches of areas can be reverted to forest and wildlife habitats.[2]

Added Nutrient Value and Healthier Foods

GM food is said to have equivalent nutritional value as the conventional non-GM food, although crops with added nutrient value can be produced, such as GM- Golden Rice having additional Vitamin A.[2]

Besides, due to lesser usage and application of pesticides, the foods produced are healthier.

Advantage of Trait Selection

The principles of Biotechnology involved in the creation of GM crops help in the selective transmission of only selected traits in a controlled and sophisticated[3] way that is not a possibility with conventional methods.

Arguments against GM Crops

Recent researches with regard to GM crops, their production, processing as well as field trials have raised serious doubts and concerns in the minds of scientists, environmentalists, and the major stake-holders i.e., consumers.

Food Quality and Nutrition

Genetic modification of plants may result in alteration in nutritional profile of the plant product which can also result in altering the nutritional status of the consumer. This can result in nutrient imbalance in the body as well as impact the overall dietary intake (FAO Corporate document repository, 2000). Currently developed plants with improved nutritive value include GM rice with enriched vitamin A and GM soyabean and rapeseed with modified fatty acid.

Food Safety

This has been the foremost area of concern in the marketing and consumption of GM Crops, and raises serious health related issues. A variant of this concern is that the inserted gene,

or even the insertion process itself, may re-engineer the biology of the plant and generate poisons or toxins.[4] The case of GM potatoes experiencing *Galanthus nivalis* lectin gene for insecticidal properties is an example of the potential of GM foods to cause toxicity. For example, in a group of rats fed with GM potato caused damage to their immune systems and stunted growth and the experiment had generated considerable controversy (ICMR, 2004).

Gene Pollution and loss of Biodiversity

The contamination of non-GM varieties of plants through pollen drift can cause loss of biodiversity. This was the reason behind the disapproval of GM Corn variety for commercialization in Mexico, as the native corn varieties might get contaminated by the foreign genes.[5]

Antibiotic Resistance—Potential for Gene Transfer

Sometimes it has also been reported that GM food (particularly Bt-Brinjal) lead to the generation of an antibiotic-resistant protein leading to alteration in blood chemistry including blood clotting time (prothrombin), total bilirubin (liver health), and alkaline phosphate in goats and rabbits.[6]

Emergence of Superweeds

As per some recent reports on GM field studies, the herbicide resistant gene that is being genetically transferred to the GM crop, can sometimes cross the species barrier and get integrated with the genome of some wild relatives of GM crops, which then become resistant to the effect of pesticides or herbicides.

Mixing of Genes "breach of religious faith"

Many religions have explicit dietary prohibitions against certain foods or consuming particular foods [Pascalev, 2003, taken from Knight (2009)]. Consensus conferences in Australia and the United Kingdom highlight lay concerns about mixing human and animal DNA with plants, being seen as tantamount to cannibalism.

Agricultural Knowledge Dissonance leading to an upsurge in farmer suicides

This is not to say that GM seeds are the sole cause of farmer's suicide, one of them, and can be explained on account of agricultural knowledge dissonance[7]. This is increasingly leading towards rejection of indigenous methods of production, and following the suite of developed nations by adopting advanced agri-based technology. Thus, all of these contribute towards farmer's distress.

Ethical Dilemma

Ethical decision making on such controversial issues will require an in-depth analysis of the various arguments and search for the truth or falsity inherent in them. The one presented here is researcher's own viewpoint with respect to the ethical perspective, and there can be varying views on the same.

S. No	*Argument*	*Type (Category)*	*Ethical Perspective*
1.	GM Crops will help in solving the problem of hunger in the country.	Social cum economic	Is there really any shortage of food that our country is facing, or is it the faulty distribution mechanism and polity of the country? (Principle of Equity)
2.	GM crops require lesser use of pesticides, and solve the problem of fund raising by poor farmers.	Economic	Is it ethical to forsake our indigenous methods of crop improvement and adopt western technology whether our croplands are suited for it or not?
3.	Crops with added nutrient value can be produced via GM technology.	Health	There can be many alternative natural sources that can provide the same nutrient value as GM crops.
4.	Consumption of GM crops can raise many health related concerns.	Health	Can the lives of millions be put at risk for the sake of technological advance of the country? (Principle of Health and Safety)
5.	GM Crops as a threat to country's own bio-diversity.	Environmental	Man-made exchange of genetic material as opposed to the natural ways having unforeseen consequences.
6.	Patenting of GM crops by western companies and forcing the Indian farmers to pay the price for it.	Economic and Political	A direct blow to the human rights as well as violation of the autonomy of Indian farmers.
7.	GM crops involve the mixing of animal and plant genes leading to breach of religious faith.	Social	Marketing Unlabelled GM food violates the trust of the consumer and goes against the ethic of virtue.
8.	GM crop as one of the contributing factor for farmer's distress.	Social cum emotional	Is GM-technology really in the right of general public or just another gimmick to bolster the economic and political gains of a few influential groups? (Principle of Beneficence)

Thus, it becomes important that addressing the ethical concerns along with the concept being covered needs to be the main aim of science education in order to sensitize students toward these issues and make them able decision-makers.

The second issue being taken up in the present paper that has recently generated a furore amongst animal right

Food Security v/s Health security
Technology advance v/s Seed Patents
Increased crop yield v/s Farmer's Autonomy
Genetic Modification v/s Agricultural Knowledge Dissonance
Increased Pest resistance v/s Breach of Religious Faith
Herbicide resistance v/s Emergence of Superweeds.

activists, ecologists, and animal conservationists is *"The Issue of Animal Experimentation".*

The publication of Peter Singer's book, "Animal Liberation", in the year 1975 has been a milestone in generating heated voices and arguments from philosophers, scientists, and animal protection groups debating the scientific and moral legitimacy of animal experimentation.

A Brief History of Animal Experimentation

Experimentation on animals is known since ancient times, dating to around 500 B.C were the older records of real anatomical observations. Studies on animals were also a central part of Aristotle's work (384-322 BC), as he is believed to have dissected over 50 species of animals. Erasistraus is considered the founder of experimental physiology and the first vivisectionist (Singer, 1996: 48-52, taken from Paixao and Schramm, 1999).

Some of the path breaking researches that can be attributed to animal experimentation include study of movement of heart and blood in animals by William Harvey (1578-1657); Conditioning in dogs by Ivan Pavlov (1890); isolation of three forms of polio virus by Jonas Salk (1940) and many others.

Arguments in favour of Animal Experimentation

Advances in Medicine and Health care (Therapeutic): Sigma Xi, the scientific research society defends the use of non-human animals in biomedical research by citing what they take to be the enormous benefits of that research:

"Results from work with animals have led to understanding mechanisms of bodily function in humans, with substantial and tangible applications to medicine and surgery (e.g., antibiotics, imaging technologies, coronary bypass surgery, anti-cancer therapies), public health (e.g., nutrition, agriculture, immunization, toxicology and product safety)..."

Research with animals has made possible most of the advances in Medicine that we today take for granted. An end to animal research would mean an end to our best hope for finding treatments that still elude us.

Generation of Knowledge and tracing Evolution through Vivisection (Non-therapeutic): Most of the medical researches as well as those done in a lot number of animal research institutions torture or kill animals for the sake of knowing the anatomical as well as physiological characteristics of certain organisms. This is usually done as part of comparative studies at the graduate and post-graduate levels, and even in

higher researches where such experiments are used to trace the lineage (evolutionary studies).

Animals as easy Models for Drug Testing: It is better that lab animals should be used than that the tests should be made directly on human beings. So far as insulin is concerned, it was only by experimentation on dogs that it came to be learnt that removal of something manufactured by the pancreas caused diabetes... In the continuing debate between experimentalists and champions of the rights of animals, the discovery of 'insulin' remains a shining example of the benefactions experimental animals have conferred upon man (Lafollette and Shanks, 1996).

Anti-Vivisectionists' Ethical Arguments

Do Animals Have Rights? Is it morally justified to cause pain or harm to one set of animals in order to provide some kind of benefit to humans? Is it justified to devalue or denigrate the life of an animal as compared to that of Humans (Regan, 2005)? All such questions pester the conscience to give a second thought to the practice of animal experimentation as a method in research.

Species Barrier as a deterrent for extrapolation of drug-testing experiments: Animals do not serve as appropriate models for medical testing of drugs and other invasive treatments, due to difference in basic physiological and psychological make-up.

One major example of animal and human differences is that of heart research being done on animals, frequently dogs. There could be varied factors responsible for heart diseases in humans such as fatty diet, irregular lifestyle, smoking, drug consumption, lack of exercise, persisting stress or anxiety, etc., none of which can be replicated in an animal[8].

The Underestimation of Human Harms: Many medicines that are not toxic for test animals prove to be highly toxic for human beings. A medical disaster, in the case of thalidomide research[9], Zomax and DES which were all tested on animals and judged safe, had devastating consequences for the people who used them. Animal testing wastes time, too, by leading researchers in the wrong direction.

Anti-Vivisectionist Organisations and Forums

Some scientists, social activists, ecologists, and wild-life conservationists joined hands together to fight for animal rights, and initiated a number of concern forums and organizations such as PETA[10] and another U.K based National Anti-vivisection Society (NAVS). These have helped in generating awareness about animal abuse and ill-treatment in our so called modern scientific society and have also unveiled the deplorable state of animals in some of the highly acclaimed research labs in India and other countries. These attribute to the faulty scientific procedures used leading to wastage, poor laboratory practices, and a lack of appropriate animal care.

Ethical Dilemma

The arguments produced herewith show us both the positive as well as the

S.No	*Argument*	*Category*	*Ethical Perspective*
1.	Majority of the advances in medicine and health care can be attributed to animal experimentation.	Health	Do human rights supersede animal right to live?
2.	All the physiological experiments at school and college level require animal vivisection for acquiring skills and knowledge.	Educational	Instead of killing and vivisecting the mute animals can't we use alternatives here such as CD ROMs, Bio-informatics, other in-vitro methods?
3.	Animals are easily available targets for drug research.	Medical	What if the positive results of animal experimentation happen to be hazardous on humans?
4.	Animals are being indiscriminately used in the labs and sometimes even in pointless wasteful experiments.	Deontological	Do we humans have any right to play God or do we have any obligation towards animals?
5.	Animals face unnecessary suffering and pain in the labs that are akin to slaughterhouses.	Emotional	Can we show moral sensitivity toward animals while utilizing them for research?

negative side of animal research along with the emotional, ethical and sensitivity quotient attached to it. This creates a kind of mental dissonance and ethical dilemma in deciding as to whether animal experimentation should constitute a method in scientific practice or not?

The major ethical issues being raised include pain and suffering to the animals, treating them as experimental objects devoid of any feeling, vivisecting them to study about the anatomical make-up, disregarding and flouting the animal rights laid down precisely by the Committee for the Purpose of Control and Supervision of Experiments on Animals (CPCSEA)*.

On the one hand, the advances in the field of medicine, drugs, and many sophisticated and non-invasive therapies can be attributed to the animal experimentation, then on the other hand an ethicomoral question

* The CPCSEA was set up 40 years ago under the provisions of the Prevention of Cruelty to Animals Act, 1960. It was meant to ensure that animals are not subjected to unnecessary pain or suffering before, during and after the performance of experiments on them; that they are procured from registered breeders; that there is no duplication of research and consequently unnecessary sacrifice of animals for the sake of research; and that experiments on large animals are avoided when the same result can be obtained by experimenting on small laboratory animals.

that arises is that do we humans have any right to play God and play with the lives of other animals, who constitute a larger proportion of sentient beings on this planet?

Another ethical issue that deserves attention is the treatment of animals in the science and research institutions and labs that are more akin to slaughterhouses, and are unhygienic and unfit for care or upkeep of animals. Thus, caging them away from their natural habitat and subjected to a life of drudgery.

Human Life v/s Animal Life
Human Medical Aid v/s Animal Suffering and Pain
Human Model v/s Animal Model for Experimentation
Human Rights v/s Animal Rights
Animal Drug Trials v/s Fatal Human Outcomes

One of the perspective in this regard has been limiting the use of animals in research given by Milburn (1989:78, taken from Paixao, R. L. and Schramm, F. R., 1999), supporting a 3r rule as per which:

The first r, 'replacement', suggests that one should seek to replace the use of vertebrates with methods employing other, non-sentient materials, including plants, microorganisms, etc. (Russel and Burch, 1992:69, taken from Paixao, R. L. and Schramm, F. R., 1999).

The second r, 'reduction', recommends one attempt to reduce the number of animals used in a given experiment by the choice of right strategy. Thus, calling for a better experimental design (Russel and Burch, 1992:105, taken from Paixao, R. L. and Schramm, F. R., 1999).

The third r, 'refinement', recommends that one seek to minimise the amount of animal discomfort or suffering (Russel and Burch, 1992:134, taken from Paixao, R. L. and Schramm, F. R., 1999). The use of anesthetic or analgesic drugs is relevant in this sense (Paton, 1993:129, taken from Paixao, R. L. and Schramm, F. R., 1999).

Recent Research Trends—Foraging Links between Ethics and Science Education

The literature review of the current trend in science education researches shows that adequate attention has been given to socio-scientific issues (Donnelly, 2004a; Donnelly, 2004b; Levinson, 2004; Levinson, 2006; Sadler, 2004b; Sadler et al, 2006; Sadler and Zeidler, 2005; Zeidler, 2003; Zeidler and Keefer, 2003; Abd-El-Khalick, 2003), although many more efforts need to be initiated in the area of applied ethics in science education both at the high school and at college level.

Science education is characterised by freedom of thought, imagination, inquiry and discovery. For years, science education has been regarded as a model for the democratic decision-making in the society we live in. But in order to acquire sound decision-making skills, training in the ethical issues in science is required. This can only be achieved

by embedding these Socio-scientific issues (SSI) in the science curriculum, so that they can be tackled with adequate care, responsibility and sensitivity.

It has been argued that science education should provide an opportunity to develop not only arguments and understanding for scientific concepts (Simon et al. 2006) but also for socio-scientific issues (Sadler and Zeidler, 2004).

Regarding values related to science, socioscientific issues (SSI) has been suggested as an important development of science education (Zeidler, *et al.* 2005). As per Sadler and Zeidler (2004), *"The most important feature of SSI is that it promotes the self-actualisation of students by providing opportunities to negotiate the morality of socio-scientific decisions on their own."*

Ethics and Science Curricula

Crosthwaite (2001) has listed three main problems in deciding the content of ethics of technology courses:

- What ethical issues to address?
- How much technological or scientific information to include?
- What to teach about ethics or morality?

Crosthwaite suggests two main aims of the courses on "Ethics of Science and Technology"

1. To produce an ethically informed community, by teaching ethics to both scientists and non-scientists (to ameliorate the present situation)
2. To produce ethical scientists and technologists, in the sense of inculcating ethical values in the students who will pursue careers in these arenas.

The second aim seems to be the most challenging, as many are uncertain about the attempt to teach morals, in the sense of instruction. What should be taught? Who decides what is right and what is wrong and how? Should one teach one's own values? What if these are minority values? What does one teach in an ethically pluralist society? All these are questions that need to be researched upon.

Teaching Ethics

There always exists a great risk of "indoctrination" in teaching which aims to inculcate morality, and some approaches to teaching morality, and some moral or ethical positions may be incompatible with other aims of teaching. For instance, can one teach the skill of informed and critically aware thinking at the same time, as one is trying to inculcate a particular view?

But, it is also not possible to teach about ethical issues in a completely morally neutral way. These tend to take a subjective stand, by supporting one particular view more often than the other. The popular methods of instruction being proposed for teaching the ethical virtue behind these socio-scientific issues by many pedagogues as well as scientists and researchers is the discussion and argumentation mode (Wallace and Louden, 2002). This includes taking into consideration students' as well as teachers' models of thinking and views/beliefs concerning a particular issue. The clashes in views is almost inevitable here and need to be resolved by inculcating decision making skills amongst the students, i.e., by

weighing the pros and cons of each and every problem.

Models of Teaching Ethics and Assessment

Levinson (2008), devised a novel method in the teaching of these controversial socio-scientific-ethical issues by way of *personal narratives*. Narratives can be considered as personal, contrived or socially constructed experiences carved around a chief educational goal. The objectives that are to be met through these narratives are predetermined, along with a sequence of events that are pre-planned and well directed. Narratives can take several forms such as drama, song, poems, or a simple interesting story line. The inherent phenomenon in each and every form of narrative is the connection with the context, which is the soul of these activities.

This method allows in bridging the gap between the local/personal and the emergent science. In the context of a controversy personal narratives help in generating diverse opinions and reaching for the best possible way out.

In some of the preeminent universities, such as the Florida State University, in USA, ethics in science has been integrated into an interdisciplinary science course called "Science, Technology and Society" (STS) (Gilmer, 1995). Students in this course become aware not only of the science itself, but also of the process of science, some aspects of the history of science, the social responsibilities of the scientists, and the ethical issues in science.

However teaching such integrated courses and at the same time assessing the students on the mastery of the same are two daunting tasks before the high school as well as university teachers. Sharing teacher's own experience of practicing science, while highlighting key incidents such as misconduct in science, discrepancy or faking of experimental data, as well as plagiarisation are some such issues. Collection of materials for teaching, such as relevant books and articles, can be sought.

Assessment procedures also vary depending upon the given issue or problems but have to be truly unconventional. Portfolios can serve a great purpose in this regard, as they display only selected pieces of student's work and demonstrate his or her learning[11].

Influence of Teacher's Identity

Cross and Price (1996) conceptualised a relationship between the teachers' social conscience and their dealing with the controversial issues in the classroom. The study included taking in-depth interviews of science teachers from two different locales, viz., Scotland and America, where many of them reflected contrasting viewpoints on dealing with the controversial issues in the class-room. Some regarded them as purely irrelevant while many remained sensitive to the issue, and felt their responsibility to educate the young generation about the pros and cons of each product of technology. The availability of teaching resources also play a pivotal role in dealing with these issues effectively, so that the issues do not just receive a two sided debate rather provide more and more

opportunities for exploration and interface between science and society.

In yet another study conducted by McGinnis and Simmons (1998) stated in a vivid manner the impact of local culture influencing the teachers' teaching pedagogy with respect to controversial issues (such as STS issues). The study is based on an ethnographic research model, and takes into account an in-depth analysis of the perceptions, working, attitude, knowledge, and strategies adopted by six middle-school science teachers in dealing with the controversial STS (Science, Technology and Society) issues. The study also regarded parents as the chief source of information and inputs on the culture of a particular community. Different cultures held different or to say defiant views regarding some of the controversial issues which they called as "taboos", and hence resisted discussions on them, whereas some of the issues had the sanction to be included in the science curriculum which were referred to as "Noa" topics.

There has always been a question of maintaining teachers' identity and authority in dealing with such controversial socio-scientific issues as the methods required in effectively dealing with them require a less obvious role of teacher in the class. This has been studied by a group of researchers (Pedretti *et al,* 2006), who developed a multimedia programme of a case in an issue-based classroom. Data was collected using observation scales, checklist with a likert-scale, open-ended questionnaires, reflective writing, work-sheets, and audio as well as video-taped conversations and interviews. The findings revealed that at some points teacher's own identities as well as personal values do intersect while dealing with the issues. Also, there happened to be some discontent regarding the course content of such issue based instruction and the mismatch with the current examination pattern. The teachers also revealed their incompetence as well as helplessness on their part, due to lack of adequate resources, training, and time. They however agree that inclusion of such issues in the curriculum would definitely address the ethical dimension of science leading towards better decision making.

Pedagogy for Classroom Instruction

In dealing with the class-room situations as well as adapting it toward the socio-scientific-ethical paradigm, the following researches are noteworthy:

1. *Media coverage* of controversial environmental issues provides *teaching contexts* which are both motivating and relevant for students (Barros and Germann, 1987). At the same time, these issues provide an appropriate setting for the emphasis on *decision making* that prominent science educators have argued is an essential component of any science curriculum (Schwab, 1974; Watson, 1980).
2. One way of helping students explore the complexity of multifaceted environmental issues is with *simulations* that involve students in *role-playing* the various stakeholders in the controversies (Bybee, Hibbs, and Johnson, 1984 taken from Geddis, 1993).

3. The use of *informal argumentation* has also been as area of active research in dealing with the SSI in the class-room, this involves generating arguments from the social, political and ethical realms rather than focusing merely on the objective and logical scientific knowledge (Sadler, 2004). Since the issues labeled as SSI can no longer be dealt by just focusing on scientific or technological part of it, as these have an impinging effect on the society at large, hence the debates or arguments need to take into account a wider purview. This creates a forum of interaction and knowledge access for the non-science majors who can simultaneously participate and learn from these discussions.
4. To free the sciences from the elitist tag as well as from the hegemony of objective, value-free and coherent approach, these socio-scientific issues need to be addressed in their most naturalistic way. Since these issues derive their essence from the community, therefore it is important that the schools or other higher educational institutions encourage and provide a whole range of learning situations that promote *involvement in community life* (both within the scientific community as well as the general public) and employ diverse forms of *team work.* This will enable sharing of opinions and at the same time being tolerant to others (Tal and Kedmi, 2006).

Towards the end of the study, a need was felt to view the present class-room scenario of the researcher's own geographical context with respect to the treatment been given to such socio-scientific-ethical issues as well as to generate teachers' opinions about integrating such issues in the Science curriculum alongside gauging their understanding on the significance of ethics in Science. Hence a pilot study at this point became mandatory.

Insights from the Pilot Study

A pilot study was conducted with a small sample of PGT-Biology teachers, University lecturers taking Biological Sciences, and students of Class-XII having Biology as one of the electives, and undergraduate students enrolled in B.Sc. (Hons.)-Zoology, IIIyr. The methodology involved taking interviews and filling up of open-ended questionnaires.

The responses gathered from the pilot study were a clear indication of the fact that ethical issues are not given their due importance both at the higher secondary and undergraduate level. The underlying causes for the same were identified as teachers' lack of awareness, focus on the content and concepts more rather than dealing with ethical dilemmas, degree of incompetence and discomfort in dealing with conflicting issues in the class-room, and no place been accorded to ethical issues in assessment and examination system.

On the other hand, student interviews and questionnaires revealed a different story altogether, they were keen to discuss such matters in the class-room, disliked plain lecturing and didactic, enjoy activity oriented teaching-learning, however one thing that seemed to be common here is the

lack of an understanding and decision-making on ethical issues amongst students both at senior secondary and under-graduate level.

Epilogue

The present paper attempts to resolve the dichotomy between the two areas of science and ethics by way of two case studies namely GM crops and animal experimentation. The main objective of it being the elaboration of each issue on scientific, social, political and most importantly ethical grounds. It presents an open forum to discuss such controversial issues on a wide platform, without displaying any biased opinion. The major debates centered on such issues, provide different perspectives to view the given problem, all of which appear to be logical and justified. However, it is left upon us to emerge through the ambiguity by taking a particular stand.

Studying the recent research trends, it can be concluded that a genuine attempt has been made to create sensitivity as well as awareness about the socio-scientific-ethical issues. The means chosen can be many such as public forums, mass media, non-governmental organisations, street plays, public participation, etc. However our focus in this paper has been creating sensitivity by way of science education and curriculum. The main stakeholders in this case being the curriculum planners, text-book writers, policy makers, headmasters, science teachers and students. Dealing with these issues requires great expertise on the part of teachers, and hence a radical change needs to be actualized in the current teacher education programme.

The classroom strategies in order to cater to socio-scientific-ethical issues also need a revamp and a renewal. Plain lecturing, demonstrating, or didactic won't serve the objective, rather discussion, argumentation, and informal reasoning should form the trend. Thus, enabling extensive student participation and involvement through community programmes. Thus, a need to adopt the socio-ethical model along with the logico-scientific method can offer some help in emancipating science and technology and creating a liberal society freed from the shackles of materialism, self-centeredness, and irrevocable destruction in the name of development.

NOTES

[1,3] Refer to Khosla, P.K. (2002), "Eco-friendly Bt. cotton and GMCs saviour of Indian farmers" in Agriculture Tribune, Monday, May 20, 2002, Chandigarh, India.

[2] Refer to Das, N. M (2006, Jan 02), 'Food Security through Genetic Engineering', The Hindu. Retrieved from http://www.hindu.com/edu/2006/01/02/stories/2006010200410200.htm

[4] Refer to Purkayastha, P and Rath, S (2010, May 15), 'Bt Brinjal: Need to Refocus the Debate', Economic and Political Weekly, XLV (20), 42-48.

[5] Anuradha, R. V (2002), 'GMOs – Promises and Concerns', Frontline', Volume 19 - Issue 08, Apr. 13-26, 2002.

[6] Refer to "India says No to Bt-Brinjal", Retrieved from http://www.bhoomimatha.com/india-says-no-to-bt-brinjal/

[7] Rejection of indigenous methods of production, and following the suite of developed nations by adopting advanced agri-based technology, whether they comply with Indian climatology and topography or not. See Vaisavi, A. R. (2004), Suicides and the Making of India's Agrarian Distress, National Institute of Advanced Studies, IISc Campus, Bangalore, India.

[8] Refer to An Anti-vivisectionist Reply to pro-vivisectionists most common arguments, with a focus on Anti-vivisectionists Unmasked (Produced by Seriously Ill for Medical Research- SIMR).

[9] See 'The thalidomide story explained', Down To Earth, April 16-30, 2010.

[10] PETA or People for the Ethical Treatment of Animals, founded by Ingrid E. Newkirk in January, 2000 is an organisation that works towards educating the policy-makers and the general public about abuse of animals in different spheres and aiming towards an understanding and promotion of animal rights and respecting them.

[11] Refer to Collins, Angelo (1991) "Portfolios for Assessing Student Learning in Science: A New Name for a Familiar Idea?", in Kulm, G. and Malcom, S. F. (Eds.) Science Assessment in the Service of Reform, American Association for the Advancement of Science, Washington, D.C.

REFERENCES

Abd-El-Khalick, F. 2003. 'Socio-scientific issues in pre-college science classrooms', Zeidler, D.L. (Ed), 'The role of moral reasoning on socio-scientific issues and discourse in science education, science and technology education library', Kluwer Academic Publishers, Dordrecht.

Barrow, L. and P. Germann. 1987. 'Acid rain education and its implications for curricular development: A teacher survey', *Science Education,* 71, 15-20.

Bybee, R., M. Hibbs and E. Johnson. 1984. 'The acid rain debate'. *The Science Teacher,* 51(4): 55-55.

Cross, R.T. and R.F. Price. 1996. 'Science Teachers' social conscience and the role of controversial issues in the teaching of science'. Journal of Research in Science Teaching, 33 (3): 319-333.

Crosthwaite, J. 2001. 'Teaching Ethics and Technology–What is Required? *Science and Education,* 10: 1-6.

DBT (Department of Biotechnology) 2007. 'National Biotechnology Development Strategy', Ministry of Science and Technology, Government of India.

Donnelly J. 2004a. 'Ethics and the Science Curriculum'. *School Science Review*, 86: 29-32.

_____ 2004b. 'Humanising Science education'. *Science Education.'* 88: 762-784.

FAO Corporate Document Repository. 2000. 'Safety Aspects of Genetically Modified Foods of Plant Origin', *http://www.fao.org/wairdocs/ae584e/ae584e05.htm*

Frankena, W.K. 1993. 'Ethics (2nd Ed)', Prentice-Hall of India Private Ltd.

Frey, R.G. and C.H. Wellman. 2003. 'A Companion to Applied Ethics'. Blackwell Publishing Limited.

Geddis, A.N. 1993. 'Improving the Quality of Science Classroom discourse on Controversial issues'. *Science Education*, 75 (2): 169-183.

Gilmer, P.J. 1995. 'Teaching Science at the University Level: What about the Ethics?' *Science and Engineering Ethics*. 1:173-180.

Grebmer, K. von, H. Fritschel, B. Nestorova, T. Olofinbiyi, R. Pandya-Lorch, Y. Yohannes. 2008. 'Global Hunger Index Report 2008'. Welthungerhilfe, *International Food Policy Research Institute and Concern*.

Indian Council of Medical Research (ICMR) Report, 2004.

Knight, A. 2009. 'Perceptions, Knowledge and ethical concerns with GM foods and the GM process'. *Journal of Public Understanding of Science*. Sage Publications,18: 177-188.

Kurtz, P. 2007. 'Science and Ethics', Prometheus Books, New York.

Lafollette, H and N. Shanks. 1996. 'Brute Science: Dilemmas of Animal Experimentation', Routledge Publications, New York.

Levinson, R. 2004. 'Teaching bioethics in science: crossing a bridge too far'. *Canadian Journal Science, Technology Mathematic,* 4:353-370.

Levinson, R. 2006. 'Towards a theoretical framework for teaching controversial socio-scientific issues'. *International Journal of Science Education*, 8:1201-1204.

_____ 2008. 'Promoting the role of the personal narrative in teaching controversial socio-scientific issues'. *Science and Education*. 17: 855-871.

Mc Ginnis, J.R. and P. Simmons. 1998. 'Teachers' Perspectives of teaching Science-Technology-Society in Local cultures: a socio-cultural analysis'. John Wiley and Sons Inc.

Minkoff, E and P. Baker. 2004. 3rd ed., 'Biology Today–An Issues Approach.', Garland Publishing, New York.

Paixao, R and F. Schramm. 1999. 'Ethics and animal experimentation: what is debated?', Cad. Saude Publica, Rio de Janeiro, 15(Sup.1), pp 99-110.

Pascalev, A. 2003. 'You are what you eat: Genetically Modified foods, integrity and Society'. *Journal of Agricultural and Environmental Ethics*, 16: 583-94.

Pedretti, E.G., L. Bencze, J. Hewitt, L. Romkey and A. Jivraj. 2006. 'Promoting Issue-based STSE Perspectives in Science Teacher Education: Problems of Identity and Ideology'. *Science and Education 2008*, 7: 941-960.

Regan, T. 2005. 'Empty Cages: Animal Rights and Vivisection', Inside Contemporary Debates in Applied Ethics (ed.), Blackwell Publishing Ltd.

Richards, S. 1983. 'Philosophy and Sociology of Science–An Introduction', Basil Blackwell Publisher.

Sadler, T. 2004b. 'Moral sensitivity and its contribution to the resolution of socio-scientific issues'. *Journal of Moral Education*, 33(3):339-358.

_____ A. Amirshokoohi, M. Kazempour and K. Allspaw. 2006. 'Socio-science and Ethics in Science Classrooms: Teacher Perspectives and Strategies.' *Journal of Research in Science Teaching*, 43(4):353-376.

_____ and D. Zeidler. 2005. 'The significance of content knowledge for informal reasoning regarding socio-scientific issues: applying genetics knowledge to genetic engineering issues'. *Science and Education*, 89(1):71-93.

Sadler, T.D. 2004. 'Informal reasoning regarding socio-scientific issues: a critical review of research'. *Journal of Research in Science Teaching*, 41 (5): 513-536.

_____ and D.L. Zeidler. 2004. 'The morality of socio-scientific issues: construal and resolution of genetic engineering dilemmas'. Science *and Education*, 88: 4-27.

Schwab, J.J. 1974. Decision and choice: The coming duty of science teaching. *Journal of Research in Science Teaching, 11,* 309-317.

Simon, S., S. Erduran and J. Osborne. 2006. 'Learning to teach argumentation: research and development in the classroom'. *International Journal for Science Education,* 28(2-3): 235-260.

Singer, C. 1996. 'Uma Breve Historia da Anatomia e da Fisiologia desde os Gregos ate Harvey', Editora da Unicamp, Sao Paulo.

Tal, T. and Y. Kedmi. 2006. 'Teaching Socio-scientific issues: Classroom Culture and students' performances'. *Cultural Studies of Science Education*, 1(4): 615-644.

Wallace, J. and W. Louden. (Ed.) 2002. 'Dilemmas of Science Teaching'. Rouledge Publishers.

Watson, F. 1980. 'Science education for survival' In C. P. McFadden (Ed.), *World trends in science education.* Atlantic Institute of Education, Halifax, Canada.

Zeidler, D. (Ed.) 2003. 'The role of Moral Reasoning and Discourse on Socio-scientific Issues in Science Education'. Kluwer Publishers, Dordrecht.

Zeidler, D.L., T.D. Sadler, M.L. Simmons and E.V. Howes. 2004. 'Beyond STS: A Research Based Framework for Socio-scientific Issues Education'. Wiley Periodicals, *http://www.interscience.wiley.com*

_____ 2005. 'Beyond STS: A research-based framework for socio-scientific issues education'. *Science and Education,* 89: 357-377.

Zeidler, D.L. and M. Keefer. 2003. 'The role of moral reasoning and the status of socio-scientific issues in science education: philosophical, psychological and pedagogical considerations'. In: Zeidler D.L.(Ed), 'The role of moral reasoning and discourse on socio-scientific issues in science education'. Kluwer Publishers, Netherlands.

WEBSITES

- www.petaindia.com/issues/default.aspx
- http://www.indiagminfo.org/updates/draft%20Biotech%20strategy.pdf.
- http://epaper.dnaindia.com/
- http://www.nuffieldfoundation.org/teacher-training-cpd-units
- http://www.erigone.com/Antidumping/Argentina/ogm_argentina_glyphosate_122pages.pdf
- http://www.bionetonline.org/english/content/ff_eth.htm
- http://www.scu.edu/ethics/practicing/focusareas/medical/conference/presentations/genetically-modified-foods.html
- http://www.nuffieldfoundation.org/sites/default/files/files/snab-cpd4-fac-9615.pdf
- http://www.nuffieldfoundation.org/sites/default/files/files/snab-cpd2-fac-9613.pdf
- http://www.nuffieldfoundation.org/sites/default/files/files/snab-cpd2-tchr-9614.pdf
- http://slp.org/pdf/others/high_tech.pdf