TEACHING BIOETHICS – A CHRISTIAN APPROACH IN A PLURALISTIC AGE[1]

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With the re-emergence of values education in the school curriculum in the last decade, science is viewed as one of the key teaching domains in which students can explore underlying beliefs and values and develop reasoning and critical thinking skills to make informed decisions on socio-scientific issues. This paper considers these issues and highlights the importance of integrating Christian values in science education in the field of biotechnology.

An investigation of the use of ethical frameworks in the teaching of bioethics is outlined. The research supports the proposition that the use of such frameworks assists students in the ethical reasoning process in dealing with socio-scientific issues.

Key words: bioethics, biotechnology, Christian education,, science teaching, socio-scientific issues

INTRODUCTION

Over the last decade, there has been a confluence of factors and trends in curriculum development, educational theory and practices and changing national policies in the Australian educational scene. Values education has emerged to be a prime focus in writing a school curriculum.. A constructivist approach to teaching practices has gained wider acceptance. Socio-scientific issues as a vital area of concern in improving active responsible citizenship is increasingly integrated in a number of cross-disciplinary subjects. The Australian National Curriculum (2010) identifies `developing ethical reasoning' and `decision-making' as key attributes in educational outcomes. Such a movement necessitates a closer look at how Christian educators can constructively and creatively address these rapid changes.

In the area of science education, there are pertinent topics such as climate change, issues of sustainability, genetic modification and organism enhancement which are currently woven into public debates and national policy making. As a Christian and a science educator, I explored the use of ethical frameworks in the teaching of bioethics.

A CHRISTIAN PERSPECTIVE

For the most part of last quarter of a century till the beginning of this new millennium, there has been a commitment to pluralism in which other views of the world were tolerated with varying degrees of civility. This involved toleration of views with which the general public disagreed, and freedom to express such disagreement publicly. Pluralism today seems to involve not only toleration but also acceptance of other worldviews as equally valid. Part of this shift comes from the privatization of one's view of the world and. one does not normally make a moral or philosophical judgement in the public arena on the worldview of another. This notion of pluralism is contrary to the admonitions of Scripture, which urge the church to critique other worldviews from the perspective of the gospel and to present the truth of Christianity as a philosophically viable and consistent alternative (refer 1 Peter 3:15; 2 Cor 10:5; Acts 17:22 – 34; Col 2:8). As we began the new millennium with an increasingly secularised culture, it is vital that the educational aspects of our bioethics curriculum enable our young people to think critically and allow Scripture to inform their scientific literacy about the development of emerging technologies and attendant applications.

The perspective towards bioethics of Protestant Christian ethicists has been predominantly one based on the character of God, the order of divine creation, the Person and Work of the Resurrected Lord and Saviour Jesus Christ, the community of faith and the eschatological fulfilment of a new future (Rae & Cox, 1999; M. Hill, 2002; Peterson, 2001; Messner, 2010; Cameron, 2011). In contrast to the dominant culture with its emphases on rights, rules, values and results, the alternative viewpoint from the Christian worldview requires a careful consideration of the three broad themes of creation, redemption and transformation which encapsulate what God is doing in the world at large, the church, families and individual lives. This includes the larger environment and the physical entities (body, genes, genetic expressions, etc). The physical bodies are to be sustained (where biotechnology permits), and should be restored when damaged or should be improved in order to serve God and one's neighbours better.

In highlighting a rationale for teaching bioethics from a Christian perspective, the writer hopes to establish this biblical focus to help us avoid the folly of reducing our knowledge of persons and their bodies to the objective and objectifying gaze of science.

A SCIENCE EDUCATOR PERSPECTIVE

We live in an age where scientific knowledge has provided human beings with an unprecedented ability to manage and manipulate life. Since the publication of the human genome, major changes are evident in a diversity of practices such as medicine, forensics, the production of bio-fuels, the development of vaccines and cleaning of polluted soil.It has become increasingly apparent that science and technology are increasing at a rate faster than human capability to comprehend fully, or evaluate effectively, the consequences of their utilisation.

Science educators from different parts of the world have recognised the importance of socio-scientific didactics to develop responsible scientific citizenship (Aikenhead, 1986; Driver, Newton & Osborne, 2000; Kolsto, 2001; Zeidler, 1984), identify the interdependence between science and society (Sadler, Chambers & Zeidler, 2004) and promote scientific literacy (Bingle & Gaskell, 1994; Driver, Leach, Millar & Scott, 1996; Zeidler & Keefer, 2003). The focus on scientific literacy, which is reflected in the standards and reform documents in the United States (American Association for the Advancement of Science, 1990; National Research Council, 1996; Siebert & McIntosh, 2001), in the United Kingdom (Millar & Osborne, 1998) and in Australia (National Statement on Science for Australian Schools, 1993; Curriculum Council of Western Australia, 1998; Shape of the Australian Curriculum: Science, 2009), maintains that science students need to develop the ability to make informed decisions regarding scientific issues of particular social import. Scientific literacy, at least in part, entails the ability to analyse, discuss, interpret relevant evidence, and draw conclusions in response to socio-scientific issues.

Reference to the term `socio-scientific issues' encompasses a range of social dilemmas with conceptual, procedural or technological associations with science (Kolsto, 2001; Patronis, Potari &

Spiliotopoulou, 1999; Zeidler, Walter, Ackettt & Simmons, 2002; Sadler & Zeidler, 2005). In general, socio-scientific issues involve some processes of science or products that generate controversy or debates. These issues may arise, for example, from gene technology such as stem cells, therapeutic cloning, genetically modified foods and reproductive technologies involving *in vitro* fertilisation, genetic screening and genetic engineering and others (relevant to the Year 10 – 12 biological course content).

Sadler (2004a) pointed out that socio-scientific research focuses on four main directions: relationships between the nature of science conceptualisations and socio-scientific decision-making, ways of evaluating information , influence of conceptual understanding on reasoning and socio-scientific argumentation in genetic engineering (Ekborg, 2008; Jimenez-Aleixandre, Rodriguez, & Duschl, 2000; Osborne, Erduran, & Simon, 2004; Simonneaux, 2001; Zohar & Nemet, 2002), environmental issues (Kortland, 1996; Osborne, Erduran & Simon, 2004; Wu & Tsai, 2007) and other public health issues (Albe, 2008; Kolsto, Bungum, Arnesen, Isnes, Kristensen, Mestad, Quale, Tonning, Ulvik, 2006; Lee, 2007). In implementing curricula, students' poor argumentation in the context of socio-scientific issues has become a concern (Boerwinkel & Waarlo, 2009; Acar, Turkmen & Roychoudhury,2010).The authors proposed that explicit teaching of reasoning and argumentation research should provide students with a decision-making framework in which they can consider their values and assess different alternatives. This is consistent with 'critical affiliation' as advocated by Hill (1994, ch. 5)

A WAY FORWARD – THE USE OF ETHICAL FRAMEWORKS.

In our investigation we used ethical frameworks incorporating Christian values as a way to help students make ethical judgements and rationally and relationally justify them. An adaptation of `Ethical Frameworks' by Michael Reiss (2008) was employed. These are categorised as rights and duties, beneficence/ non-maleficience, autonomy and communicative virtues. The adaptation was to include Christian moral ethics and the following is a description of the resulting five.

Balancing rights

Rights define what people can expect as their due, so far as it is under the control of people or human society. There is always a duty associated with a right, though in many cases, the duty on other people is simply that they do not interfere with or prevent others claiming their rights. Any right an individual has relies on other people carrying out their duties towards that individual. If people neglect their duties, then other people's rights may be neglected.

Maximising the benefits

This framework balances the benefits of an action against the risks and costs. It promotes the common good to help people have a fair share of the benefits in a society, a community or a family. It is often described as `the greatest happiness for the greatest number'. It could be seen as a `right' to override the rights of individuals in order to bring about happiness in the wider community.

Making decisions for yourself

People act autonomously if they are able to make their own informed decisions and put them into effect. For this to happen, people should be provided with access to relevant information on the issue under consideration.

Leading a virtuous life

This framework supports the `rightness' or `wrongness' of actions. An action can be described as right or wrong independently from any consequences of the action. It is dependent on fair treatment and the fair distribution of resources or opportunities.

Christian moral ethics

For the Christian the Scriptures provide the basis and motivation upon which a decision is based. This framework promotes the values undergirding the belief which centres on the person, work and teachings of Jesus Christ who, through his life, death and resurrection points to the nature and character of God, the Father and whose work continues on earth by the Holy Spirit.

The controversial issues to which these frameworks were applied were in the area of human genetics and transgenic plants in Australia.

To illustrate the application of the framework it is applied to an issue that was used during the second week of the program identifying the type of reasoning approach that can fall under each ethical category.

Pre-natal Genetic Screening

The Socio-scientific Issue: Pre-natal genetic screening not only carries the risk of miscarriage, it also leads to the possibility of abortion where the test result is positive. Most people would not consider getting rid of a child or an adult with a genetic disorder such as Down Syndrome or cystic fibrosis – a newborn baby with either of these conditions is offered medical care and support to lead the fullest possible life. How can it be right to abort the same individual a few months previously, as a result of genetic screening?

Some issues arising from pre-natal genetic screening:

- These procedures present a risk of miscarriage to possibly healthy foetuses. Other risks include: safety, accuracy of techniques, accurate communication, consent, adequacy of counselling and psychiatric support pre/post-abortion
- Are parents given free and properly informed choice about whether or not to abort a foetus found to have a gene disorder?
- Should the social, financial, happiness and health considerations of the parents be given more weight than the baby's right to life?
- Issues surrounding controversial requests such as appropriateness for individuals, sex selection or anxiety about a child's medical condition
- Fairness of access (socio-economic priority of genetic services)

Table 1 shows the application of the five frameworks in this case.

Table 1 The Use of Ethical Frameworks in the Issue of Pre-natal Genetic Screening

5 Ethical Frameworks	**Socio-scientific Issue – Pre-natal Genetic Screening**
Rights and Duties	Every individual, born or unborn has the right to life. Rights of a foetus may conflict with the rights of the mother if the pregnancy presents risks to the mother's physical or mental health (issue of paternalism versus autonomy in counselling). Parents, medical professionals and society have a duty of care towards an individual before and after birth.

	The question of access to human genetic services also raises the issue of what priority the society (eg. socio-economic priority of services) and its policy makers want to place on this type of medical intervention (prenatal diagnosis).
Maximising Good in the World	It is unethical to bring a child with a genetic disease to the world if it will result in suffering of the individual, reduce the happiness of parents and family, or drain the financial resources of society. Selecting healthy children will strengthen, rather than weaken the gene pool, reducing the number of faulty genes in the population. People with severe physical or mental disabilities are often able and active citizens, contributing greatly to society. Judging an individual's fitness to live on the basis of genetic disorders may deny society the benefits of these people's contributions.
Making Decisions for Yourself	Parents may have to make a special commitment to a child with disability. It is up to parents to decide if they are willing and able to do this. Medical professionals need to take time and care to explain the full implications of a positive result in pre-natal genetic screening. Unless the parents understand the range of potential scenarios, positive and negative, they are not in the position to make the necessary decisions. Nurses and doctors who do not wish to participate in abortions should have their wishes respected.
Leading a Virtuous Life	A `good' society is prepared to love and care for individuals irrespective of their physical or mental capacities. Allowing pre-natal screening to take place is only acceptable in a limited range of cases. These include cases where early detection of a disorder will improve the effectiveness of post-natal treatment and care. Abortion could be seen as virtuous in cases where genetic disorder produces a great deal of suffering and misery for the individual with the disorder.
Christian Moral	Love is the foundation of Christian ethics. In the Christian tradition, one has an obligation to help the vulnerable and a special obligation to one's children (looking out for the least, poor and vulnerable, Deuteronomy 10:18 and 1 John 3:17). Scriptural principles call for care for the vulnerable and extending love to neighbour as widely as possible. Embryos have the moral status of persons and should not be killed regardless of the extent of human benefit, Genesis 1:27 states that man is made in the image of God.

METHOD – ACTION RESEARCH AND CASE STUDY

The research design was a case study approach based on the understanding that `a case study is an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when boundaries between phenomenon and context are not clearly evident' (Yin, 2009). In this case it required an understanding of the contextual conditions which were highly pertinent to the particular phenomenon under study here, namely the development of adolescents' ethical reasoning linked to science ability. A mixed method design was utilised where qualitative and quantitative research techniques, methods, approaches or language are combined into a single study (Johnson & Onwuegbuzie, 2004). This approach was selected to addres complicated research questions and enable a richer and stronger array of evidence to be collected.

The investigation focussed on the use of a constructivist student-centred model in Year 10 Biotechnology classes taught over a period of ten weeks in an inter-denominational evangelical Christian college in Perth, Western Australia. There was one control group of 31 students and an experimental group of 29 students, both taught by different but equally experienced teachers.

Arrangements were made to control variables other than the one under study. The two teachers developed a profile of shared core beliefs about socio-scientific education, pedagogy in teaching such issues, rationale for the current research, the definitive of a collaborative classroom working environment and the number and type of teaching and learning strategies to be used. Both teachers essentially shared the same program by the use of a detailed overview. This contained general outcomes, specific outcomes, and for each week the content, key concepts, teaching strategies, data collection and method of evaluation.

Students in both control and experimental groups were introduced to the fundamentals of argumentation and reasoning processes in a special session on `Ethics and Reasoning' by a Philosophy and Ethics teacher before embarking on the biotechnology unit.

In teaching the unit a series of case studies was used to help students develop their reasoning skills and the two groups were given equal time for this. They differed in the use of ethical frameworks to help students structure their arguments before making a decision based on careful consideration of alternatives and options, in each case using an appropriate decision-making template. This asked 'What is the problem?', 'Describe your feelings about this problem'. It then required further consideration. On it, for the control group space was provided for two choices followed by positive and negative consequences for each one leading to 'My Decision' and 'Reflection and justification of the decision'. For the experimental group the choices were replaced by responses to each of the five frameworks.

Qualitative data was generated throughout the course by the observation of students' participation in the activities in class, analysis of written case studies, weekly journals, post open-ended questions and post interviews that were digitally recorded. A teacher's questionnaire was also designed to obtain constructive feedback from the teacher after the course (where ethical frameworks were implemented in the experimental class). Weekly teacher interviews were also conducted to discuss specific observations of each lesson. Quantitative data was obtained by the use a pre-and post-course test consisting of a sample of short case studies, and from questionnaires using five point Likert scales. One of these was designed to assess students' attitudes to specific aspects of biotechnology. Some of the items are shown in Appendix 1. Another questionnaire (Appendix 3) sought to evaluate their attitudes to biotechnology as an entity.

SGNIFICANCE IN THE USE OF THE ETHICAL FRAMEWORK APPROACH

Based on the SPSS analysis of the pair sample testing of pre-and post-questionnaires (Appendix 1), students in the experimental group show an increased appreciation for the use of ethical frameworks as a good strategy to handle science and biotechnology issues. Pair 9A states: 'The use of ethical frameworks is a good strategy to better understand and deal with science and biotechnology issues.'

As shown in Table 2 the increase in the mean score of the experimental group was statistically significant.

Table 2. Item Mean, Standard Deviation and t-test for Students' Perception of the Usefulness of the Ethical Frameworks

Pair	Item Mean		Item Standard Deviation		Difference
	Pre	Post	Pre	Post	t
9A	3.69	4.15	0.74	0.68	5.09***

***$p < 0.001$

No significant difference was found for the control group.

The effectiveness of the actual use of the frameworks was measured by the pre- and post-tests consisting of short case studies. Here is an example.

The case was: 'Using *in vitro* fertilization and genetic screening techniques, it is possible to screen embryos before they are implanted. Using this technique, it is possible to select the gender of a child or even make sure that it does not have certain diseases.. In the future, it may even be possible to select for other traits such as eye colour or intelligence.

Agree/ Disagree

Outline as many reasons as possible.'

The responses were examined in terms of the reasons given, the use of evidence and the use of ethical principles, and scores were allocated. For the category 'Students provided reasons when agreeing or disagreeing to the idea' scores were allocated as follows:

0 for no reasons, 1 for 1-2, and 2 for 3 or more. A total score from all the cases was obtained for each student. The results given in Table 3 indicate that there was no difference between the groups initially but in the post-test the mean score for the experimental group increased significantly.

Table 3. Item Mean, Standard Deviation and t-tests for the Uses of Ethical Frameworks

Test	Item Mean		Item Standard Deviation		Difference
	Experimental	Control	Experimental	Control	t
Pre	3.84	3.75	0.46	0.83	0.53
Post	4.03	3.88	0.55	0.72	2.46*

*$p<0.05$

The differences between the groups may be attributed to the use of the five ethical frameworks. These provide students with a range of alternatives to base or anchor their thoughts and ideas and initiate a series of progressive arguments and counterarguments to reach a decision-making point. This was supported by the journal entries triangulated with interviews. It also inspires confidence and increases assurance in dealing with the more complex socio-scientific issues and provides a good starting point to encourage students in the thinking process including evidence-based and ethical reasoning in coming to a point of view and defending it. Students move from 'what to think' to `how to think'. The use of the fifth Christian framework enables students to identify and appreciate how Christian values can play a significant role in shaping decisions critical to life issues, supported by scientific knowledge.

In terms of growth in the complexity of argumentation, students in the control group moved from using one reasoning approach to two or three to justify the decisions they made but were less integrative in nature compared to those in the experimental group where a proportionately greater number of students used two, three or even four ethical frameworks to shape their argumentation and reasoning process.

In the use of ethical frameworks students can be invited to see their own bias and embrace a more objective point of view, being drawn to consider data not just from personal experience or pure intuition, but also scientific data and the social issues involved. Students develop a greater depth in their response to justify a particular viewpoint. The results of the triangulation method using student interviews, teacher's records and group discussion notes (recorded on tape) provided supporting evidence (refer to the following samples of journal entries):

-`*The ethical framework helps me to think more clearly about the issue that is presented. It also helps me to see the different ways a person can think about a situation*.' EE

`*The ethical framework has helped me to view issues and situations from different perspectives; helps me to consider all views with all or most of the frameworks*.' VA

`*I think the ethical frameworks can be more effectively used if cases are more varied and different because at times, they were quite similar. This would mean more of the frameworks could be used to form decisions*.' JS

`*Yes, it has allowed me to provide my reasoning and has given me a structure to rely on when making a decision … I found this course of study very interesting. Thank you*.' ST

Consideration was given to the influence of teaching the unit on the students' attitude to biotechnology as an entity. The evaluation included their concern about its use and their behaviour as indicative of the willingness to use biotechnology. The Likert scale shown in Appendix 3 was used and the scores of the students in the two groups were combined for this purpose.

As shown in Table 4 the mean score for the positively constructed items showed a significant increase indicating that students' attitude to biotechnology became more positive. However, the mean score for the negative items displayed a slight, but not significant, decrease. It is unclear why this occurred. Given the reliabilities of the two subscales it could be that they are measuring slightly different things. Perhaps the greater reference to genetic research in humans and animals in the negative items is indicative of this. It suggests that further development of the scale could be helpful. However, it would be unrealistic to expect a considerable change in the attitude to the complex field of biotechnology during the limited time of this intervention.

Table 4 Mean, Standard Deviation and t-test for Attitude towards Biotechnology and Reliability of the Scales.

Scale	No of Items	Test	Mean	S D	Difference t	Alpha Reliability
Positive Constructed	13	Pre	2.95	0.46	3.22**	0.71

		Post	3.16	0.46		
Negative Constructed	17	Pre	3.18	0.52	1.56	0.83
		Post	3.10	0.54		
Concern	4	Pre	2.65	0.85	2.54*	0.64
		Post	2.41	0.78		
Behaviour	4	Pre	2.62	0.97	0.25	0.80
		Post	2.65	0.95		

**$p<0.01$, *$p<0.05$

The decrease in the mean score of the `concern for the use of biotechnology' is indicative that students were less affected. This decrease might suggest students' growing confidence in handling biotechnology issues even if the overall attitude has not changed. The items in the behaviour group have a greater personal impact and perhaps this explains why no change was found in this category.

In focusing on the use of ethical frameworks as one approach towards developing ethical reasoning and decision making, it is recognised that this needs to be complemented by a variety of teaching strategies. Such teaching strategies include small group discussions, debates, role-plays, case studies, open forums and multi-media interactive activities. Within the ten-week program, both classes had at least three different teaching strategies used per week (e.g. a debate /role play/ lab session, a small group discussion / in-class written activity/research/ case study analysis and an hour lesson on content delivery in one week).

Equally significant is the role of the teacher whose core beliefs and philosophy of teaching serves to shape the entire enterprise with procedural neutrality yet inspiring confidence towards a decision-making point without being authoritarian or morally relativistic. The role model of the Christian teacher is vital in equipping and empowering students to embody the Christian values and beliefs in dealing with difficult socio-scientific issues. I have discussed this at greater length in my previous article on `Integrating Faith in the Science Curriculum' (Yap, 2010, p.18 -21).

Finally, exploring the ethics of socio-science issues in a meaningful way extends the thinking of students to embrace a bigger perspective of the issue at hand and view the contribution of science on a larger scale as well. This may be noted from the following contributions by both control and experimental group.

Journal entry from a control group student's diary:

` *I learnt about all the different issues and viewpoints surrounding certain aspects of biotechnology which included surrogacy and donor organ transplants. I found the viewpoints especially the ethical and religious viewpoints interesting and some made me think twice about my viewpoint and whether I was thinking the right way. My conscience sometimes tells me that what I was thinking wasn't necessarily ethically right. I find other viewpoints about these issues interesting and would like to hear other viewpoints about cloning and designer babies.*'

Journal entry from an experimental group student's diary:

`*Learning about ethical frameworks was really helpful because I now know how to make decisions about many issues we faced with today or may face in the near future. The frameworks provide a basis on which I can hold my views and also a basis for reasoning with decision I made about the ethical issues brought up. It is really interesting what we are studying in this unit. There are so many issues that we face in society and the difficult decisions we have to make. It is hard to know what is right and what is wrong. We need to understand why something is right or wrong and how our values affect our answer to the question*.'

For students who integrate their Christian faith with their learning experience, the bigger perspective means embracing the Christian worldview and seeing in definitive ways how they can be better stewards of God-given resources.

LIMITATIONS AND IMPLICATIONS

It has been suggested that research could be directed towards strategies of instruction about the formal structure of argument (Kuhn, 1991). Such instruction was provided in somewhat limited proportion for both the control and experimental classes, specifically the two sessions on `Ethics and Argumentation'. It is recognised that increasing this level of explicit instruction on argumentation would raise the efficacy of the ethical reasoning process.

Even given the arrangements to control the teacher variable some differences in teaching style occur. This resulted in a variation in the data collection in particular with the journals. The control teacher

encouraged journal writing on a weekly basis and the experimental teacher implemented it on a daily basis.

In research of this kind the Hawthorne effect can be significant. This was given careful consideration during the interviews where clarification was often made to ensure that the interpretation by the teachers was consistent with what the students were actually conveying in the class and their written responses.

The present study was conducted in a Christian college which provided some degree of homogeneity in the faith aspects of our Christian values-based framework. Perhaps, this research can be taken in a further direction by exploring its effectiveness in a school setting with greater diversity in terms of religious values and/or in a more pluralistic context. This would provide interesting insights as to how faith, values and religiosity influence or shape the moral/ethical reasoning process.

The time pressure imposed by the new national curriculum might cause difficulty in using the variety of teaching strategies which are needed. The ideal duration for a Year 10 Biological Science program on the biotechnology unit is recommended to be 8 weeks which was the actual running time of this program (excluding two weeks for assessments and college activities).

CONCLUSION

This research supports the view that effective use of ethical frameworks in the reasoning process in dealing with socio-scientific issues serves to engage students, enable students to exercise value judgements, promote conceptual learning of related content, support scientific argumentation and develop critical thinking, evidence-based reasoning and decision-making skills.

It is hoped that in a small but significant way this study contributes towards the vision of making bioethics education more effective and faith-engaging in dealing with the complexities of the modern, pluralistic and genomic society.

ENDNOTES

1. This article incorporates a more in-depth approach to the content presented at the Scholarly Symposium at the International Transforming Education Conference in Darwin on 11 July 2011 as well as the Fourth International Conference for Science and Mathematics Education in Penang on 15 November 2011.

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Appendix 1. Evaluation of Students' Attitude and Reasoning about Biotechnology

Tick the column that gives the best indication of your feelings about each statement.

		Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Gi
1A	Problems resulting from science or biotechnology hardly ever affect me.						
1B	Problems resulting from science or biotechnology will only affect some people in our society.						
1C	Problems resulting from science or biotechnology will affect an entire country, and even the world.						
2A	I would like to know how problems in science or biotechnology affect me.						
2B	Most people will not act on science and biotechnology even if they understand why action is needed.						
2C	If I knew more about science and biotechnology issues, I could do more about them.						
3A	There should be some guidelines provided by the government to solve science and biotechnology problems.						
3B	Science and biotechnology should use a problem-solving approach.						
4A	The government should give priority to problems of biotechnology affecting humans first.						
4B	The government should give priority to problems of biotechnology affecting both humans and animals.						
4C	The government should give equal attention to solving problems of biotechnology affecting humans, animals and the environment.						
8A	Members in society have the responsibility to develop the appreciation and respect for the rights of others within the society.						
8B	All science classes should include science and biotechnology issues and topics in the curriculum.						
8C	Open discussions using scientific knowledge and ethical principles should be encouraged in science and biotechnology teaching.						
9A	The use of ethical frameworks is a good strategy to better understand and deal with science and biotechnology issues.						
9B	It is important for students to be taught how to think through critically and make decisions about science and biotechnology issues.						

What is the number one Science and Biotechnology related issue facing the world today?

Why do you think this?

Appendix 2. Four Scenarios Questionnaire

For each of the following biotechnologies, indicate whether you agree or disagree with the technology and provide as much detail as possible why you made your decision, including any ethical or moral principles that influenced your decision.

1	Genetically modified food is food that has been grown from plants that have had their genome changed by deliberately removing genes or adding genes from another organism. This enables scientists to alter specific characteristics of the plants. Plants are often given genes that provide resistance to disease or herbicides. Genetically modified crops produce more food and farmers do not have to use as much chemicals. Other plants have been genetically modified so that they are drought and disease resistant or more nutritious. These crops could greatly help in the fight against world hunger and malnutrition.
	Agree Disagree *Outline as many reasons for your selection that that you can.*
2	Using *in vitro* fertilisation and genetic screening techniques, it is possible to screen embryos before they are implanted. Using this technique, it is possible to select the gender of a child or even make sure that it does not have certain diseases. In the future, it may even be possible to select for other traits such as eye colour or intelligence
	To what extent do you agree or disagree with this technology? *Outline as many reasons for your position as you can.*
3	Many otherwise healthy couples are unable to bear children. Modern reproductive technologies, like fertility drugs and *in vitro* fertilisation, have enabled some of these individuals to have their own children. However, some couples remain infertile and unable to have a baby. For these individuals, cloning could be used as another reproductive technology. In this case, one of the parents would serve as the genetic donor. The donor's genetic material would be inserted into an egg cell, and then the embryo (the egg carrying a complete set of the donor's genetic material) would be implanted into the woman. The embryo would develop into a foetus and eventually be born as a baby.
	Agree Disagree *Outline as many reasons for your selection that you can.*
4	In therapeutic cloning, cloning a cloned embryo is created and the stem cells removed. The stem cells are stimulated to grow into specific types of tissues and even possibly whole organs such as a kidney, which could then be used for organ transplants. Two major problems that are associated with organ transplantation are a lack of available organs, and immunological rejection. Organs and tissues produced by means of therapeutic cloning would solve both of these problems. Patients awaiting transplants could donate their own genetic material for the production of the cloned embryo and the immune system would not reject it.
	Agree Disagree *Outline as many reasons for your selection that you can.*

Appendix 3. Attitude, Concern and Behaviour Relating to Biotechnology

Indicate how strongly you agree or disagree with each of the following statements by ticking the appropriate column from strongly agree (SA) to strongly disagree (SDA).

		SA	*A*	*N*	*DA*	*SDA*
1.	Genetically modified foods can help solve food problems in third world countries.					
2.	Biotechnology makes our lives healthier, easier and more comfortable.					
3.	The natural resources of the earth will soon be exhausted because of the advances in biotechnology.					
4.	Genetically modified food is a threat to future generations.					
5.	Further research will solve any dangers associated with genetic modification.					
6.	Genetic research in humans is wrong.					
7.	I think that the genetic modification of food is unnatural.					
8.	The genetic modification of animals is wrong.					
9.	Animals have rights that humans should not infringe upon.					
10.	Genetic modification is a threat to nature.					

11.	Genetic modification in humans is 'playing God'.					
12.	Genetic techniques can easily be abused.					
13.	The genetic modification of bacteria will result in future problems.					
14.	I think that biotechnology is advancing too fast.					
15.	It is difficult to find anything positive about the applications of biotechnology					
16.	I am uninterested in biotechnology					

17.	Biotechnology is essential for future survival.					
18.	The genetic modification of plants does not exceed the limits that humans should not cross.					
19.	Eating genetically modified food is dangerous					
20.	Genetic research in animals will benefit human health.					
21.	Genetic research in animals is absolutely unnecessary					
22.	Genetic modification is a necessary part of modern life.					
23.	Studying genetics in humans is of no value.					
24.	Genetic research in humans is essential.					
25.	I have faith in science.					
26.	I would buy genetically modified food if it were available at my local supermarket.					
27.	I would not eat at a restaurant if the food they served contained genetically modified ingredients.					
28.	I would buy genetically modified food if it were cheaper than ordinary food.					
29.	I would eat genetically modified food if it tasted better than ordinary food.					
30.	I would eat genetically modified food if it contained less fat than ordinary food.					

How concerned are you about the following areas of biotechnology? Tick the appropriate column from very concerned (VC),moderately(MC),slightly(SC),unconcerned (UC),unsure (U)

		VC	*MC*	*SC*	*UC*	*U*
31.	In Vitro fertilization					
32.	Genetic Research					
33.	Genetic modification					
34.	Cloning					

Would you be willing to do the following? Tick the appropriate column from definitely (D), Probably (P), Maybe (M), probably not (PN), definitely not (DN).

		D	*P*	*M*	*PN*	*DN*
35.	Take a genetic test during you or your partner's pregnancy?					
36.	Take a genetic test to find out whether you are at risk of a serious illness when you are older?					
37.	Undergo gene therapy to correct your genes if tests showed that you were highly likely to get a serous genetic disease later?					
38.	Allow your child to undergo gene therapy to improve or change their genes if your child suffered from a severe or fatal genetic disease?					