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SOLI DEO GLORIA
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FOREWORD

As we enter the second decade of the new millennium, educational endeavours in the field of science have seen increasing interest in the role science plays in contemporary decision making and problem solving. The importance of scientific literacy and active citizenship in making informed decisions about science practices and applications is underlined by an increasing awareness of taking into account the ethical and social implications that come with science advances in technology and its inherent societal impact. The Australian Curriculum (2013) acknowledges this significance by including the ‘Science as a Human Endeavour’ strand which is described in a two-year band, notably the second sub-strand as follows:

**Use and Influence of science:** *This sub-strand explores how science knowledge and applications affect people’s lives, including their work, and how science is influenced by society and can be used to inform decisions and actions.*

In this respect, this strand with its emphasis on informed decision-making, necessitates teaching practices that seek to develop the students’ general capabilities in critical and creative thinking, intercultural understanding and ethical behaviour.

This book is written as part of an initiative to implement the *Science as a Human Endeavour strand* in middle school science (directed at Year 9 and 10) in the area of biological sciences. It is recognised that the biological curriculum with its emphasis on form and function of living things from cells to systems, reproduction, genetics and biotechnology provide fertile ground for cultivating students’ ability to integrate scientific knowledge with facts about ethical principles and knowledge of cultural and societal values.

The introduction of bioethics in middle school years provides opportunities for students to develop their informal reasoning, argumentation and decision-making skills – capabilities that will assist them to engage with more complex issues they are likely to encounter in the near future and to navigate a world of competing values, rights, interests and norms.

Finally, this book is written to address the current paucity of teaching and learning activities for teaching socio-scientific issues with reference to moral reasoning in science education – a need that was articulated in recent research papers (Van der Zande et al., 2009, 2012). It is hoped that in some way, that this book will contribute towards the developmental trajectory of a science teacher’s teaching of socio-scientific issues, and in turn, enhance student-centred learning, improve scientific literacy as well as strategically develop responsible, active citizenship among the young people.

Dr Siew Fong Yap
CHAPTER 1 – INTRODUCTION

Theoretical Underpinnings

Research in science teaching in the recent decade shows that there has been a growing emphasis on teaching scientific content in relation to socially relevant life situations referred to as situated learning (Boersma et al., 2007; Van Aalsvoort, 2004) and the use of socio-scientific issues (Albe 2008; Grace, 2009; Lee et al., 2013; Sadler, 2004). Socio-scientific issues are ill-structured problems for which solutions are indefinite and complex (Baxter Magolda, 1999; Kuhn, 1991; Zohar & Nemet, 2002), and essentially incorporate two main elements: (1) connections to science content, and (2) social significance. Due to the controversial nature of socio-scientific issues, its high relevance to society and its inclusivity of a range of viewpoints, socio-scientific issues is potentially engaging and igniting enthusiasm amongst students. In developing their own positions on socio-scientific issues, students learn not only to incorporate scientific knowledge and data, but also reason with due consideration to ethical, moral, social and economic aspects of the problem (Sadler, 2009). Socio-scientific issue learning in conducive learning environments has been shown to engage students in processes of data analysis, reasoning, argumentation, and decision-making. The learning environment is one that encourages respectful collaboration and active listening and students taking ownership for their learning in such an environment (Sadler, 2011).

What is ‘ethical thinking’ and ‘ethical reasoning’?

**Ethics** is a branch of study concerned with deciding what is morally right or wrong. This can apply to matters ranging in complexity governed by a few features. They can range in focus. Some concern what individuals do. Others pertain to how one handles one-to-one relationships. Yet there are others about how we should act as a group. There are concerns pertaining to non-human world and other matters may range from the present to the future; for example, this concerns how and what we do now affects people (or the environment/the earth) in the future. In addition, complexity arose because of the different forms of language associated with it; commands and rules, settled habits of action and feeling (eg. ‘care’ and ‘honesty’) and weighty abstract terms (e.g. ‘right’, ‘injustice’, ‘freedom’, ‘exploitation’). Finally, there are many areas of life included in this realm of ethics.

While it is inevitable that some moral decisions have to be made, ethics is a form of discipline which involves some kind of reasoning and thoughtful analysis so that we can justify why we make those decisions. Justifying one’s decision and action does not necessarily make the action right or wrong. That is, the validity of our ethical conclusion may be called to question. Concerns about the validity and worth of an ethical conclusion can be addressed by checking if three criteria are met (Reiss, 1999). **First**, if the arguments that lead to the ethical conclusion are well-substantiated by reason. **Second**, if the arguments are consistent within a sound ethical framework. **Third**, if an acceptable degree of consensus is found in the validity of the conclusions, which has come about as a result of an authentic debate. The use of such a criterion to determine the validity of an
ethical conclusion is helpful provided reason is a sole guiding factor. In dealing with ethical issues, reason alone cannot be relied upon; perhaps the ‘reasonableness’ of an ethical reasoning is the preferred indicator. In this regard, there is no single universally accepted framework within which ethical questions can be decided by reason. Nevertheless, ethical frameworks can be useful as guidelines in developing ethical reasoning and providing a structure for considering alternatives, clarifying values and justifying decision-making.

How is ethical thinking and reasoning promoted through the teaching of socio-scientific issues?

Ethical thinking and ethical reasoning are developed in the teaching of socio-scientific issues through the use of argumentation. On socio-scientific issues, argumentation can be justified using content knowledge in a more or less sophisticated way (multiple or simple justifications, plural or single disciplinary ones), but also, and often mainly on values. Social, cultural, moral and sometimes religious issues influence students’ argumentation on socio-scientific issues. Kolsto (2006) argues that students should be taught that science involves epistemic and social values. The purpose of teaching socio-scientific issues is to promote students’ understanding of controversial issues, to develop student’s open-mindedness, thirst for more information, and ability to identify bias and reflect critically (Oulton et al., 2004; Sadler 2006; italics emphasis mine). The capacity to offer a coherent, logically consistent argument that included an explanation and rationale for the position taken, multiple-perspective taking and the ability to identify bias and reflect critically incorporates ethical thinking and ethical reasoning processes.

Thus, ethical/moral reasoning is developed from the process of argumentation and discourse. On the one hand, it is a competency whereby students can evaluate potential decisions with respect to how well decisions are based on scientific knowledge, evidence and data and the extent to which they attend to potential short-term and long-term consequences. On the other hand, it extends beyond more scientific/technical competence in as far as the student must consider how well their decisions attend to the issue of what is fair, just and equitable. Such reasoning arises out of a special type of reflexive judgement that transcends competency in decision-making because there is a value judgement involved, and this adds to the formation of conscience and empathy, integral to the larger context of moral/ethics development, norm acquisition and character formation.

Relevance of socio-scientific education in the Australian Curriculum

The National Curriculum Framework Core Values for Australian Schooling (2010) clearly indicates that the teaching of socio-scientific issues has a place in the science and citizenship curricula. In the section on Achievement Standards for Year 10 Science, the following was noted.

By the end of Year 10, students are able with some guidance to demonstrate the ability to use scientific evidence in their decision making and in developing arguments about science-related issues. They evaluate how advances in science and technology have impacted on society and environment and use scientific knowledge across a range of sciences to critique claims and propose responses to contemporary issues (e.g. genetic engineering, biodiversity and sustainability). They can identify distinct branches of science and can give examples of the multi-disciplinary nature of much contemporary science.
In highlighting the seven general capabilities as key dimensions of the Australian Curriculum, two of the attributes, namely *critical thinking* and *ethical behaviour* are highlighted. These attributes can be cultivated through the teaching of socio-scientific issues in the science curricula. In particular, socio-scientific education is recognised as essential in the implementation of the Science as a Human Endeavour strand of the Australian Curriculum in Science because it reinforces the three inter-related organising elements of the ethical behaviour learning continuum in the Australian Curriculum (2012):

1. Understanding ethical concepts and issues
2. Reflecting on personal ethics in experiences and decision-making
3. Exploring values, rights and ethical principles

Such a focus and impetus is similarly threaded through the Senior Secondary Science Curriculum (Biology) where the rationale and aim are articulated in terms of providing a foundation for students to ‘critically consider and make informed decisions about contemporary biological issues in their everyday lives’ and to ‘develop the ability to use sound, evidence-based arguments creatively and analytically when evaluating claims and applying biological knowledge’ (Australian Curriculum, 2013).

What are the teaching strategies and how are they effective in promoting ethical thinking and ethical reasoning?

Due to the ill-structured and controversial nature of socio-scientific issues, teaching strategies that are effective in promoting ethical thinking and reasoning, utilise classroom debates, role-plays, use of ethical frameworks, small group discussions and collaborative learning, and uses of media.

1. **Classroom Debates** are considered as a potential way for improving conceptual change (Sadler & Zeidler, 2005) or for improving knowledge on the nature of science (Bell & Lederman, 2003). Using debate as a teaching strategy enables students to recognise pseudo-scientific statements and learn to apply scientific knowledge in the ‘real world’. The importance of values in debates is seen in decision-making on real-life scenarios such as ‘biological conservation issues’ (Grace & Ratcliffe, 2002). Through debates, students articulate and listen to different points of views expressed and whilst, being confronted with opposing arguments, students clarify their thoughts on a given subject.

2. **Role-plays** encourage multiple-perspective taking and stimulate deeper reflection on counter-position arguments. The theoretical underpinnings behind the use of role play in science learning are based on active, experiential or student-centred learning. Odegaard (2003) in her review of literature on drama activities in science education, emphasized that the appropriate use of drama with reflective science teaching, could provide a creative and non-authoritative learning environment for students. Role-playing is a process that goes beyond the learning of mere facts or rote learning. It enables the creation of circumstances for effective learning through communication, co-operation, improvisation and argumentation. It allows more opportunity for students to engage in interactive dialogue and to construct meaning together with the teacher in an active role (Wilson and Spink, 2005). Research has also indicated that role-play/drama-oriented activities could be one of the creative and effective ways of developing the nature of science among young students (Cakici & Bayir, 2012).
3. **Use of ethical frameworks** – In addressing the needs for socio-scientific education, practical work alone is insufficient to create the bridge between observation and the ideas of science (Wellington & Osborne, 2001). The focus is essential for both the minds-on activity, such as the written discourse, as well as the hands-on activity. In line with this view, thus, when conducting scientific inquiries, students need opportunities to reflect on what they are doing while engaging in talking, reasoning, analysing, writing and sharing findings. In this regard, recognising the importance of teaching of science as inquiry in socio-scientific education also means emphasizing to students that science involves the construction of arguments, proposing knowledge claims based on evidence from data accessed in the inquiry or reasoning process (Yore, et al., 2003). In a recent study of current research concerning ways to foster student participation in scientific argumentation, Cavagnetto (2010) found that authors of 25 of the 54 reviewed articles revealed some combination of ‘scaffolds’ such as prompts [i.e. explicit instruction], strategic selection for group collaboration and the use of student misconceptions [e.g. engineering situations to motivate argumentation]. Such a combination is vital because ‘One must see the point of argument if one is to invest significant effort in it and in developing the skills it entails’ (Kuhn & Udell, 2007). These recent efforts underline the importance of designing classroom activities to provide a purpose for the argumentative interactions that enable students to understand how they should be involved in those types of interactions. In this book, one of the strategies used is through the use of writing frames such as the ethical frameworks where students are engaged actively with and constructing arguments, and as a result, learn to think critically and actively implement appropriate reasoning strategies.

4. **Small group discussions and co-operative learning** – Socio-scientific discussions within the science classroom can contribute to the development of pupils’ scientific literacy by exposing pupils to contemporary science content and allow them to experience and practise critical thinking skills. For the teacher, carefully instigating and managing small group discussion can provide a suitable starting point. Bennett et al. (2010) suggest that although many curriculum policy documents advocate greater use of small group discussion, there is considerable uncertainty on the part of teachers as to what they are required to do to implement good practice. Co-operative learning has been extensively recognised as a useful teaching approach for the promotion of socialisation and learning among pupils, through working together in small groups to achieve shared goals, across different subjects (Cohen, 1994). One of the many benefits, especially relevant to the goal of ethical thinking and reasoning, is the claim that when pupils work co-operatively, they learn to share ideas and perspectives, listen to each other with particular emphasis on how things are said, give and receive help, seeks ways to resolve difficulties and actively work to construct new understandings and learning (Johnson & Johnson, 2003). Some researchers regard co-operative learning, collaborative learning, peer learning and group learning as distinct and different forms, whereas others use them interchangeably to define a process in which students at all levels of ability work together in small groups to achieve an educational task (Boehm & Gallavan, 2000; Boud, Cohen & Sampson, 1999).

Regardless of which definition, it is clear that co-operative learning is a pedagogical approach which has the flexibility in terms of its application to different theoretical perspectives and to various educational contexts. In the context of developing ethical
thinking, it is an effective way to foster positive attitudes to working collectively, to develop critical thinking, and provides a way to expose students to multiple perspectives (Day & Byrne, 2011, p.6) which impinge on any discussion. Its use by science teachers allows the development and practice of skills which provide a platform from which pupils learn the basics of democratic citizenship, in particular, how to develop, hold and defend their informed opinions, based on evidence (argumentation skills), and how to argue the merits of their opinions as well as how to be constructively critical of the arguments of others without being critical of the individual (social skills). In addition, students also learn how to present counter-arguments and deal with contradictory evidence.

5. **Use of Media and Media Literacy** – A sound approach to promoting ethical thinking and reasoning in socio-scientific issues necessitates that goals are set to teach students to criticise media texts and understand them as constructed views (Ideland, 2002; Jarman & McClune, 2007). This is not always evident from research on science teacher’s lack of knowledge in media literacy leading to injudicious use of media in science classrooms (Jarman & McClune, 2002; Ideland et al., 2012). Media literacy, if successfully modelled by teachers, can be effective in facilitating critical thinking, developing argumentation and ethical evaluation among students. In the use of ethical frameworks, media articles and documentary films provide some of the raw primary sources of information to stimulate discussion, critical and creative thinking and in-depth analysis of contemporary issues. It is thus important for the teacher to use with discernment the mass media in the science classroom in a conscious way to encourage dialogic interactions between students and develop a greater understanding of how knowledge claims are constructed in science and how informed decisions are made.
Table 1 provides some examples of pedagogical approaches used to address socio-scientific issues used in the science classrooms.

**Table 1** A Range of Pedagogical Approaches Used to Address Socio-scientific Issues

<table>
<thead>
<tr>
<th>Scientific Evidence-Based Reasoning</th>
<th>factual references and exercises that include KWL (Know Want to Learn), PMI (Plus Minus Interesting), think-pair share, concept mapping, concept cartoons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case studies</td>
<td>examine a case assuming stakeholder roles to analyse an ethical issue</td>
</tr>
<tr>
<td>Systematic learning</td>
<td>about specific societal aspects of one major biotechnology eg. biotechnology</td>
</tr>
<tr>
<td>Media</td>
<td>video clips, DVD presentations, newspaper reports of current events (local, national and global setting/context)</td>
</tr>
<tr>
<td>Writing Frameworks</td>
<td>advantages/disadvantages, pros/cons, ranking exercise, writing position/perspective paper; ethical frameworks</td>
</tr>
<tr>
<td>Debates</td>
<td>traditional class debate to analyse pros and cons of an ethical issue</td>
</tr>
<tr>
<td>Role Playing</td>
<td>students assume stakeholder roles to analyse ethical issue</td>
</tr>
<tr>
<td>Oral presentations and written reports</td>
<td>followed by small group discussions</td>
</tr>
<tr>
<td>Online forum</td>
<td>discussions and computer based tools</td>
</tr>
</tbody>
</table>
Table 2 summarises examples of ethics classroom strategies that integrates students’ understanding of the nature of science and ethical reasoning utilising a social constructivist approach in a collaborative classroom setting/environment.

**Table 2 Ethics Classroom Strategies (Adapted from Chowning & Fraser, 2007, pp.28 – 31)**

<table>
<thead>
<tr>
<th>Ethics classroom strategy</th>
<th>Description of strategy</th>
<th>Activity/medium used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identifying questions that are ethical in nature</td>
<td>Students distinguish between ethical questions and other types, and learn how to ask ethical questions.</td>
<td>Small Group Discussions</td>
</tr>
<tr>
<td>Understanding how to reason and develop an argument</td>
<td>Students distinguish between inductive and deductive reasoning and learns how to develop an argument.</td>
<td>Teacher Presentation/Role modelling and small group discussions</td>
</tr>
<tr>
<td>Identifying pros/cons using ethics</td>
<td>Students explore both the positive and the negative implications of a decision made on an ethical dilemma (socio-scientific issue)</td>
<td>Small Group Discussion Individual Reflection and Analysis</td>
</tr>
<tr>
<td>Position analysis</td>
<td>Students analyse an ethical position or perspective taken by an author of a news article or an opinion essay</td>
<td>Think Pair Share Small Group Discussion Whole Class Discussion</td>
</tr>
<tr>
<td>Understanding different ethical perspectives</td>
<td>Students use simple, classic dilemmas (case studies) to learn or reinforce their understanding of different ethical theories and perspectives.</td>
<td>Think-pair-share, Small Group Discussion Whole Class Discussion Individual Reflection</td>
</tr>
<tr>
<td>Ethical theories and perspectives in role plays</td>
<td>Students assume different roles (in drama skits) that highlight different ethical perspectives.</td>
<td>Small Groups Whole Class Participation</td>
</tr>
<tr>
<td>Introduction to decision – making framework</td>
<td>Students learn how to apply a decision-making model to an ethical dilemma (or socio-scientific issue).</td>
<td>Think-pair-share Small Group Discussion Individual Reflection and Analysis</td>
</tr>
<tr>
<td>Ethics classroom strategy</td>
<td>Description of strategy</td>
<td>Activity/medium used</td>
</tr>
<tr>
<td>---------------------------</td>
<td>-------------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>Same perspective, different arguments</td>
<td>This group strategy shows students that one ethical perspective can be used to argue both sides of an ethical dilemma.</td>
<td>Small Group Discussion Whole Class Discussion</td>
</tr>
<tr>
<td>Case study</td>
<td>Student examines a case in order to analyse an ethical issue (real life or imaginary)</td>
<td>Individual Reflection and Analysis</td>
</tr>
<tr>
<td>Debate</td>
<td>Students engage in a traditional class debate to examine an issue.</td>
<td>Class Participation</td>
</tr>
<tr>
<td>Documentary film analysis</td>
<td>Students use a documentary to analyse arguments based on facts/opinions, to analyse pros/cons, and to map arguments to ethical perspectives.</td>
<td>Movie/DVD Presentation Class Discussion Individual Reflection and Analysis</td>
</tr>
<tr>
<td>Narrative ethics</td>
<td>Students analyse how perception of an issue is influenced by the way it is presented.</td>
<td>Movie/Discussion Class Discussion Individual Reflection and Analysis</td>
</tr>
<tr>
<td>Sample policy letter</td>
<td>Student crafts a letter to the head of an organisation or government official advocating for a particular policy.</td>
<td>Individual Reflection and Analysis</td>
</tr>
<tr>
<td>Letter to the editor</td>
<td>Student writes a letter of response to the editor of a newspaper concerning his particular position/stance on an issue.</td>
<td>Individual Reflection and Analysis</td>
</tr>
<tr>
<td>Online forum discussion and web-based interactive activities</td>
<td>Students engage in web-based inquiry science environment to develop questioning techniques about bioethical issues.</td>
<td>Small group and individual reflection and analysis</td>
</tr>
</tbody>
</table>
What is the role of the teacher in teaching socio-scientific issues?

The role of teacher in teaching socio-scientific issues is crucial, in particular with the status of their neutrality. The teachers who choose a committed impartiality position may see their role as part of the social-critical current. The conviction is one who believes the main task is to identify the quality of the sources used for debates, highlight the limitations of scientific facts and the social repercussions which would enable students to participate in debates as critical citizens. The observation that committed impartiality is chosen suggests that teachers will eventually be prepared to get involved in a co-operative approach with students based on the socio-constructivist theory, emphasizing the importance for learning of interactions between students as well as students and teachers.

In argumentation environments, Jimenez-Aleixandre (2008, p.98) describes the role of the teachers as follows:

(i) To model and guide inquiry because inquiry and argumentation goals both serve the same purpose; and inquiry contexts provide appropriate environments for argumentation to take place. For Brown et al. (1993), the teacher models scientific inquiry so ‘children witness teacher’s learning, discovering, doing research, reading, writing.’

(ii) To encourage students to provide evidence to justify a position (Simon et al., 2006), for example, ‘to ask open questions aimed at eliciting justifications’ (eg. Why do you think that? How do we know it?) and to challenge ideas pointing out its limitations or inconsistencies.

(iii) To develop and provide criteria for the construction and evaluation of arguments

(iv) The approach requires teachers to be ‘asking open questions and acknowledging students’ contributions in a neutral way, that these questioning strategies encourage greater student participation, elicit students thinking, and support student reflection during class discussions’(van Zee & Minstrell, 1997, p.258). The dialogic aspects of argumentation essential for classroom practice in bioethics education entail the teacher’s use of different instructional strategies and role-modelling patterns of different classroom discourses, argumentation, evidence-based reasoning, debating and counter-argumentation (Martin & Hand, 2009) and the use of ethical argument components, either as prompts (Osborne, et al 2004) or as a written rubric (Sandoval & Reiser, 2004). Some instances of criteria are: for arguments, good arguments include true, reliable and multiple justifications, refer to alternative arguments, and rebut them (Zohad & Nemet, 2002); for evidence, appropriate evidence is specific and came from data and not from opinion (Kenyon et al., 2006).

(v) To translate epistemic goals related to argumentation into oral forms of communication. Some examples of argumentation processes reflected in teacher verbal communications coded by Simon et al. (2006) are: talking and listening; knowing meaning of argument; constructing arguments, evaluating arguments or counter-arguing and debating.

(vi) To encourage students’ reflection about their positions, about changes in position as a consequence of the teaching sequence or the debates, and about the reasons underlying that change (eg. Simon et al., 2006).
The role of the teacher in teaching socio-scientific issues models inquiry, encourages the use of evidence and students’ reflection, and provides criteria for evidence. In sum, teachers have to scaffold the development of epistemological understanding. Teachers will also need to use more of their experiential worldly knowledge to effectively navigate students through a maze of data, misinformation and passions.

Socio-scientific education needs to de-mystify science so it is no longer represented as a ‘static body of facts but rather a social endeavour where culture and discourse play prominent roles’ (Yerrick & Roth, 2005, p.18). Students need to participate and develop an understanding of how knowledge claims are constructed in science. To achieve this end, teachers need to adopt a “procedural neutral stance by acting as a facilitator and students are encouraged to explore a range of viewpoints without being limited by that of the teacher” (Yap, 2010, p.18). Such a framework provides a scaffold where both teaching and learning practice can be established on a structured basis to map out the reasoning process and build sound argumentation through a careful consideration of alternatives, values, beliefs as well as evaluation of various outcomes.

What kind of learning environment is conducive to teaching socio-scientific issues?

The teaching of socio-scientific issues, in particular with argumentation practice, can only take place effectively in a well-structured classroom environment (Passmore, 2012). The role of the teacher as a facilitator is crucial to supporting productive argumentation among students. Teachers play an important role in defining the goal of the argument and in keeping students focussed on the role of the model. The successful application of the framework as a structure for supporting authentic, student-centred arguments depends upon the ability of teachers to both see the value of a model-based approach and convey the value to the students. This clearly points to the need to understand how teachers understand and use the curricular scaffolds. Overall, the classroom environment that supports the teaching of socio-scientific issues, has established norms and expectations for student participation, and these set the stage for a collaborative and interactive environment in which students and teachers can engage in discourse and reasoning processes. There is a high level of mutual respect between teachers and students and both parties feel safe within the environment.

How can we evaluate the level of ethical reasoning that takes place in teaching socio-scientific issues?

Development of test instruments for measuring students’ competence in reasoning and decision making are still subject to debate because science education research on these competence areas are still comparably new and measurement procedures are more intricate in comparison to test instruments for scientific knowledge, for example. In addressing this lack, more efforts needs to be expended in finding out what students gain by engaging in socio-scientific enquiry (Sadler, Barab & Scott, 2007). With regard to the assessment of socio-scientific competence in reasoning and decision-making, researchers have explored the use of trade-offs (Seethaler & Linn, 2004; Wilson & Sloane, 2000) and cut-offs in weighing decision criteria (Hogan, 1999, Hong & Chang, 2004) and prioritizing conflicting values (Bogeholz & Barkmann, 2005; Jimenez-Aleixandre, 2002; Kolsto, 2006) or reflecting on argumentation and reasoning processes (Sadler & Zeidler, 2005). These
are commendable efforts to identify students' competencies as well as development of such competencies. Eggert and Bogelholz (2009) developed a test instrument to measure competencies in socio-scientific decision making based on the Rasch Partial Credit Model and succeeded in establishing a hierarchy of different strategies in terms of increasing difficulty. To respond to some of the difficulties encountered in students' decision making competence, Kolsto (2006), among others, suggests that presenting different reasoning patterns can be a means to induce meta-reflection about decision-making processes and inherent value conflicts and thus can be a way of fostering students' decision-making competence.

The suggested model for use in this book seeks to complement the evaluation of decision-making competence by also identifying and evaluating the number of different reasoning patterns used in resolving dilemmas of socio-scientific issues as well as using a decision-making code as a measuring instrument. This is an adaptation of the model used by Sadler and Zeidler (2005). This model is based on the evidence demonstrated in the form of rationalist, emotive, intuitive informal reasoning and moral reasoning.

1. **Rationalistic** informal reasoning described reason-based considerations.
2. **Emotive** informal reasoning described care-based considerations.
3. **Intuitive** reasoning described considerations based on immediate reactions to the context of a scenario.
4. **Moral** informal reasoning described considerations based on one's values and belief system.

Based on the four types of informal reasoning described above, a code for the combination of the reasoning approaches was established as shown in Table 3.

<table>
<thead>
<tr>
<th>Code</th>
<th>Reasoning Represents</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>Rationalistic only</td>
</tr>
<tr>
<td>E</td>
<td>Emotive only</td>
</tr>
<tr>
<td>I</td>
<td>Intuitive only</td>
</tr>
<tr>
<td>RM (M)</td>
<td>Rationalistic and Moral</td>
</tr>
<tr>
<td>EM (M)</td>
<td>Emotive and Moral</td>
</tr>
<tr>
<td>IM (M)</td>
<td>Intuitive and Moral</td>
</tr>
<tr>
<td>No Response</td>
<td>Null response</td>
</tr>
</tbody>
</table>

The framework of informal reasoning can be visually conceptualised in the form of a Venn diagram as shown in Figure 1 on the following page. Each circle represents one of the approaches of informal reasoning (i.e. rationalistic, emotive and intuitive) with the moral reasoning represented by a shaded equilateral triangle enclosing a non-shaded circle, denoting a complement set of moral reasoning (Yap, 2012).
A teacher's confidence in teaching socio-scientific issues can be built through the active involvement in the construction of the learning activities that foster argumentation. In this respect, coaching is recommended. This can take place in a positive environment that would support reflection and feedback regarding actual classroom experiences. The act of encouraging teachers to construct their learning activities also promotes ownership as well as sharpens understanding of educational goals. The style of the program should in itself, reflect the pedagogy of teaching argumentation, that is, teachers should have ample opportunities to engage in challenging argumentation concerning various topics. The strategies in this book offer some suggestions as to how teachers can construct their own learning activities, which in turn, help build confidence in teaching socio-scientific issues.

Progressive teachers are honest about their knowledge limitations and are willing to take calculated risks. They are willing to deal with uncertainties in the classroom and also positions oneself as contributing knowledge rather than arbitrating as a sole authority on that subject. As the teachers begin to tap into their own ability to draw out connections from social and ethical issues back to the scientific content at hand, they can build confidence in their ability to promote students' use of evidence-based data to form deeper conceptual understanding of scientific information. This goes beyond the rather ineffective skills of merely pointing out science-technology-society type connection to social issues when only teaching in a more conventional manner.
Summary
In the development of the pedagogy for any approach/model to promoting ethical thinking and reasoning in socio-scientific issues, it is important to adopt a constructivist approach to the learning situation. At the same time, it is necessary to guide and structure students' exploration of material by providing frameworks for ethical deliberation, which students can adopt. The teacher has to select issues (from a range of different contexts) and questions that will facilitate exploration of the sort of understanding that one hopes students will acquire. A student-centred model requires as much teacher reflection on the aims and objectives of teaching as the preparation of a blackboard of materials to be learned.

In seeking to develop increasing ethical awareness and ethical reflection in the community of inquiry, the teacher creates a classroom environment that facilitates collaboration and mutual exchange and respect for different viewpoints and outcomes. The learning environment is one that is characterised by thoughtful deliberation and informed discussion so that issues are thoroughly explored and debating the issues form a basis for informed social decision making. In addition, encouraging students to reflect metacognitively on the process of debate and the use of ethical frameworks to map out the reasoning/argumentation process in which they are engaging is also an important part of socio-scientific education.

Finally, it is vital that the teachers develop confidence and media literacy and embrace the teaching role as one that is not authoritative but facilitative in a well-structured collaborative learning environment. This is crucial in involving students in constructing and facilitating the evaluation of knowledge, discerning the use of less focus on single correct solution pathways as well as modelling and strengthening competencies in ethical reasoning, informed decision-making argumentation and discussion which are valuable tools for active and responsible citizenship.
References


CHAPTER 4

TEACHING STRATEGY 3 – USE OF ETHICAL FRAMEWORKS

TEACHER’S NOTES

A Model Used in a Year 10 Science Classroom on a Biotechnology Unit

Making good ethical decisions requires a trained sensitivity to ethical issues and a practiced method for considering all the ethical aspects of a decision and weighing the considerations that should impact our choice for a specific course of action. In this respect, having a method or a framework for ethical decision making is essential. When practiced regularly, the method becomes familiar as one works through it systematically without being conscious of the specific steps. The more complex and difficult the ethical choice we face, the more one needs to rely on discussion and dialogue with others about the dilemma.

The use of ethical frameworks makes provisions for a systematic consideration of multiple insights and perspectives before one can make a good ethical decision about a specific situation or scenario. The use of ethical frameworks hence contributes towards a pedagogical strategy that facilitates students’ critical thinking, argumentation and decision-making skills. It also provides a process that helps students make ethical judgements and rationally and relationally justify them.

The ethical frameworks used in the classroom teaching strategies are not simply prescriptive for using socio-scientific issues; they do not provide a lock-step sequence of teacher and student activities. There is a recognizably a measure of flexibility which allows them to cater to variance in issues, learning goals and classroom situations.

The Five Ethical Frameworks

The five ethical frameworks explored in this model is an adaptation of ‘Ethical Frameworks’ by Michael Reiss (2008). These ethical frameworks are categorised as rights and duties, beneficence/non-maleficence, autonomy and communicative virtues. The fifth ethical framework can be pluralism or in this model, a Christian moral ethic is applied here.

The following is a description of the five ethical frameworks that students are to be provided to help them decide whether it is ethically acceptable or not in considering socio-scientific issues.

1. Balancing Rights (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. So it follows that if people neglect their duties towards that individual, then other people’s rights may be neglected.
2. Maximising the Benefits (Utilitarian)

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. This framework 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.

3. Making Decisions for Yourself (Autonomy)

Autonomy is concerned with the respect due to individuals. People act autonomously if they are able to make their own informed decisions and then put them into effect. The principle of autonomy is the reason why people should be provided with access to relevant information, for example, before consenting to a medical procedure or taking part in a medical trial.

4. Leading a virtuous life such as ensuring justice (Virtue)

Justice is about equality, fair treatment and the fair distribution of resources or opportunities. For example, private medical care could be seen as making superior resources available only to those who can pay; alternatively, it could be seen as providing a ‘choice’. This framework supports the moral ‘rightness’ or ‘wrongness’ of actions. An action can be described as right or wrong independently from any consequences of the action. It is not the consequences that make an action right or wrong, but the principle or motivation on which the action is based.

5. Christian (moral) ethics

This framework is based on the principles and standard stipulated in the Scripture (The Holy Bible). The Scripture provides the basis and motivation for which a decision is based. This framework promotes the values undergirding the belief which centres on the person, the work and the teachings of Jesus Christ whom, through his life, death and resurrection points to the existence of a Triune God and to the nature and character of God, the Father and whose work continues on earth is instrumental by the Holy Spirit.

The fifth ethical framework illustrated in these activities is based on Christian ethics as an example how a particular worldview can provide an avenue where students can express their ethical thinking/decision making based on the morals and values integral to the faith beliefs. This fifth framework can be modified to integrate other faith values and beliefs such as pluralism, postmodernism, Judaism, Hinduism, Islam etc.

But as a whole, the five ethical frameworks are established based on three ethical building blocks; primarily; primarily deontology (Greek ‘dei’ – must or duty), virtue (Greek ‘virtus’ – skill, strength and excellence) and teleology (Greek ‘telos’ – end, purpose or goal). The principles may be drawn from revelation from different religions’ scriptures or from various world religions or from reasoning as in some kind of universally accessible natural law (Aristotle, Dharma, Talmud, Roman Catholic canon, biblical canon or Quran).
In the context of many and varied competing ethical perspectives, we need a comprehensive ethical framework as provided above. This framework provides a process for making ethical judgements as well as avenues to rationally and relationally justify them. Students can reason and articulate their ethical framework clearly so that they are equipped to make ethical decisions as well as challenge the flaws, if any, in other ethical frameworks that may confront them in the future.

The features of the controversy that are made explicit to students through the use of ethical frameworks are specifically in the area of human genetics and transgenic plants in Australia. Such a model can be applied in the realm of bioethics within the context of an ethically pluralist society.

Table 4 provides the ethical frameworks template. Students can identify the problem within the socio-scientific context and provide one or more reasons alongside the five ethical frameworks, followed by the decision made and a concluding reflection and justification.
### Table 4

**Ethical Framework Template**

<table>
<thead>
<tr>
<th>What is the problem?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Describe your feelings about this problem.</td>
</tr>
</tbody>
</table>

### Five Ethical Frameworks

<table>
<thead>
<tr>
<th>Balancing Rights</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximising the Benefits (Utilitarian)</td>
</tr>
<tr>
<td>Making Decisions for Yourself (Autonomy)</td>
</tr>
<tr>
<td>Leading a Virtuous Life (Virtue)</td>
</tr>
<tr>
<td>Christian (Moral) Ethics*</td>
</tr>
<tr>
<td>My decision</td>
</tr>
<tr>
<td>Reflection and Justification of Decision</td>
</tr>
</tbody>
</table>

*This ethical framework can be adapted to include “Pluralism/Religious/Faith/Value*
Table 5 is an example of an activity that can be conducted in discussing a socio-scientific issue to help facilitate students in identifying the type of reasoning approach that can fall under each ethical framework. Each student is given the five ethical frameworks with its corresponding reasoning approach not linked in the order as shown, and they are to sort out the ‘jigsaw’ and match them together. This is followed by the next step where they would write out their own reasoning next to each ethical framework (this is done either individually or after a small group discussion). Refer to Student’s Page – Task 1 and Task 2.

Table 5 Example A – Pre-natal Genetic Screening


The Christian moral framework has been added to the original worksheet (Yap, 2012).

The Bioethical 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 genetic 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 child’s medical condition
- Fairness of access (socio-economic priority of genetic services)
Use of Ethical Framework in a Bioethical Issue on Pre-natal Genetic Screening

<table>
<thead>
<tr>
<th>Five ethical frameworks</th>
<th>Bioethical Issue – Pre-natal Genetic Screening</th>
</tr>
</thead>
</table>
| Rights and Duties (Deontological) | 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 (Consequentialism) | 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 (Autonomy) | 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.                                                                                                           |
Five ethical frameworks | Bioethical Issue – Pre-natal Genetic Screening
--- | ---
**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 in Deuteronomy 10:18 and 1 John 3:17).
Scriptural principles call for care for the vulnerable and extending neighbour’s love 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.
**Extension:** Students are asked to identify and discuss issues related to other types of genetic screening. Examples of issues arising from pre-conception, pre-implantation and adult screenings are provided as follows:

**Pre-conception Screening**
- Are the parents counselled adequately so they understand the interpretation of positive and negative results?
- A positive result for the presence of a faulty gene raises issues around possible duties to inform other related family members.
- Pre-conception screening may reduce the number of abortions carried out after pre-natal screening and pre-implantation screening.

**Pre-implantation Screening**
- Unwanted healthy embryos will be discarded along with embryos containing the faulty gene.
- Issues linked to selective abortion include justification and election.
- Attitudes to disabilities are raised by the technology enabling us to select for healthy embryos.
- Should we use all the technology we have at our disposal to try to ensure the healthiest babies are born?

**Adult Screening**
- Should a person identified with a gene for late-onset disease (e.g. Huntington's Disease) be screened before they are old enough to give informed consent?
- Should children of a person identified with a gene for late-onset disease be screened before they are old enough to give informed consent?
- Is screening voluntary, for example, does it take place as part of an unrelated medical procedure?
- Problem of veracity in communicating to the community the true purpose of genetic screening (e.g. BRAC1 gene and the Angelina-Jolie effect)
- Problem of stigmatisation of detected carrier as a result of poor education and information about the meaning of the carrier trait
- Problem of lack of informed consent in large scale screening programs
- Debate about screening affected persons for a disease for which there is no therapy such as Huntington's Disease
- Problem of confidentiality of findings of genetic screening that result in harm to detected carriers (e.g. loss of employment)
The activity shown in Table 5 can be followed by an application of the use of ethical frameworks in resolving another dilemma in a different socio-scientific context for further practice. The types of reasoning used by students in their decision making process are identified and analysed in the evaluation of the students' ethical reasoning capabilities from both the verbal and written discourse.

Table 6 Example B – Genetically Modified Food

The Bioethical Issue – The genetic engineering of plants causes some people to feel moral concern for a variety of reasons.

Issues raised from genetically modified plants are:

The intrinsic objections pertain to the 'unnaturalness' of the intervention. It is 'unnatural' to tamper in this way with the plant kingdom. The extrinsic concerns are socio-economic ones that centre around the ethical principle of fairness.

- Is it fair that small farmers and vulnerable economies may be losers from this technology?
- Is it fair to allow such seeds to be patented?
- Is it fair to use and profit from genetic resources taken from poorer countries?
- How does the ethical arithmetic work out?

Use of Ethical Framework in a Bioethical Issue on Genetically Modified Food

<table>
<thead>
<tr>
<th>Five ethical frameworks</th>
<th>Bioethical Issue – Genetically Modified Food</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rights and Duties (Deontological)</td>
<td>To constrain the production in a world of hunger is wrong and even immoral. Failing to proceed with promising technologies may be seen to be morally reprehensible as running the risk of producing undesirable consequences. Possibility of undesirable effects resulting from an activity does not mean that the activity should be morally condemned and banned. There is a place for appropriate political and legislative measures to put to place to regulate activity.</td>
</tr>
<tr>
<td>Maximising Good in the World (Consequentialism)</td>
<td>Genetically modified food provides a solution to feed a hungry world by producing a greater yield. However, developed countries tend to benefit from a technology at the expense of developing countries. There is the issue of control and exploitation but the benefits far outweigh the risks.</td>
</tr>
</tbody>
</table>
### Five ethical frameworks

<table>
<thead>
<tr>
<th><strong>Making Decisions for Yourself (Autonomy)</strong></th>
<th><strong>Bioethical Issue – Genetically Modified Food</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>It is imperative to weigh the costs and benefits to reach a clear ethical decision. Priorities have to be assigned to competing costs and benefits. It is recognised that technology alleviates human suffering (world hunger).</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Leading a Virtuous Life</strong></th>
<th>Based on fundamental value judgments, one ought to act so that institutions which profit from the new technology must seek to minimize the losses of the most vulnerable economies and individuals. One must advocate a cautious, well-regulated, step-by-step approach as the most responsible way forward</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Christian/Moral</strong></td>
<td>Rejection: What God has made is inherently good, do not tamper with nature. GM is too exploitative in nature. Caution: Participate responsibly in God’s work of creation. Concept of stewardship: To subdue the world to benefit mankind. Acceptance with caveats – GM plants is used in the sense of ‘restoration’ as part of God’s redemptive plan in action. The idea is that genetic engineering can help overcome genetic defects caused by harmful mutations. Thus, genetic engineering can help restore creation to a fuller, richer existence and can play an important role without encroaching on the scope of divine activity.</td>
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<td>-----------------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
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</tbody>
</table>
Evaluation of Ethical Reasoning from Student’s Responses

Table 7 – ACARA Science as a Human Endeavour Strand for Year 9 and 10 Science

Science as a Human Endeavour Strand of the Australian Curriculum
1. Understanding ethical concepts and issues
2. Reflecting on personal ethics in experiences and decision making
3. Exploring values, rights and ethical principles

<table>
<thead>
<tr>
<th>Year 9 Science</th>
<th>Year 10 Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature and Development of Science</td>
<td>Nature and Development of Science</td>
</tr>
<tr>
<td>• Scientific understandings, including models and theories, are contestable and refined over time through a process of review by the scientific community</td>
<td>• Scientific understandings, including models and theories, are contestable and refined over time through a process of review by the scientific community</td>
</tr>
<tr>
<td>• Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries.</td>
<td>• Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries.</td>
</tr>
<tr>
<td>Use and Influence of Science</td>
<td>Use and Influence of Science</td>
</tr>
<tr>
<td>• People can use scientific knowledge to evaluate whether they should accept claims, explanations or predictions</td>
<td>• People can use scientific knowledge to evaluate whether they should accept claims, explanations or predictions</td>
</tr>
<tr>
<td>• Advances in science and emerging sciences and technologies can significantly affect people’s lives including generating career opportunities</td>
<td>• Advances in science and emerging sciences and technologies can significantly affect people’s lives including generating career opportunities</td>
</tr>
<tr>
<td>• The values and needs of contemporary society can influence the focus of scientific research</td>
<td>• The values and needs of contemporary society can influence the focus of scientific research</td>
</tr>
</tbody>
</table>

Outcome: Student is able to state a personal opinion about an ethical issue, justifying this by using the ethical principles and/or given ethical frameworks

Assessment Rubric Type 1

<table>
<thead>
<tr>
<th>Four Types of Informal Reasoning</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Rationalistic informal reasoning described reason-based considerations</td>
</tr>
<tr>
<td>2. Emotive informal reasoning described care-based considerations</td>
</tr>
<tr>
<td>3. Intuitive reasoning described considerations based on immediate reactions to the context of a scenario.</td>
</tr>
<tr>
<td>4. Moral informal reasoning described considerations based on one's values and belief systems.</td>
</tr>
</tbody>
</table>
### Assessment Rubric Type 2

**Outcome:** Student is able to state a personal opinion by providing claim, data, warrant, backing and qualifier to justify a viewpoint.

<table>
<thead>
<tr>
<th>Level</th>
<th>Student is able to state the following:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsatisfactory</td>
<td>Claim statement only</td>
</tr>
<tr>
<td>Limited Satisfactory</td>
<td>Claim (statement, conclusion, proposition)</td>
</tr>
<tr>
<td>Satisfactory</td>
<td>Claim, data (evidence supporting the claim) and/or warrant (relationship between the claim and the data)</td>
</tr>
<tr>
<td>High Satisfactory</td>
<td>Claim, data, warrant, backing (an assumptions to support warrant) or qualified (a condition under which the claim is true)</td>
</tr>
<tr>
<td>Very High Satisfactory</td>
<td>Claim, data, warrant, backing (some assumptions) and qualifiers (several conditions under which the claim is true).</td>
</tr>
</tbody>
</table>

**Suggestion to teachers:** You may create your own teaching activities based on the use of ethical frameworks by mix-matching method as shown here, or apply to different socio-scientific issue/context, involve students in creating the argument based on one or two ethical frameworks, have students create a counter-argument using different ethical framework using the list of ethical teaching strategies provided on pages 7 and 8.
Using the Ethical Frameworks – Socio-scientific issue – Pre-natal Genetic Screening

LESSON OBJECTIVE

Task 1 – Students can identify issues related to a specific socio-scientific issue (eg. pre-natal genetic screening) and integrate ideas related to these issues in a concept map.

Task 2 – Students can use the ethical frameworks to reason and argue for the decision made in relation to a specific socio-scientific issue.

AUSTRALIAN CURRICULUM STANDARDS/OUTCOMES

Year 9/10 Science as a Human Endeavour Strand

Nature and Development of Science
- Scientific understandings, including models and theories, are contestable and refined over time through a process of review by the scientific community
- Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries

Use and Influence of Science
- People can use scientific knowledge to evaluate whether they should accept claims, explanations or predictions
- Advances in science and emerging sciences and technologies can significantly affect people’s lives including generating career opportunities
- The values and needs of contemporary society can influence the focus of scientific research

General Capabilities and Cross-curriculum Priorities
- Critical and creative thinking
- Ethical Behaviour
- Personal and Social Competence

ACTIVITY FOR STUDENTS – Introducing and Implementing the activity

Recommended Time: Two 45-minute class periods

TASK 1 Identifying the issues related to genetic screening

Brainstorm some of the ethical issues associated with genetic screening. Draw a concept map/graphic organiser.
**TASK 2** Using the Ethical Frameworks – Socio-scientific issue – Genetically Modified Food

Read the following statement about the ethics of pre-natal genetic screening.

> 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?


**Glossary Terms**

- **Cystic fibrosis** is an inherited metabolic disorder which is caused by a mutation of the gene on chromosome 7 that codes for a protein that controls ion flow in and out of cells. Individuals suffering from cystic fibrosis produce viscous mucus that clogs the lungs and the digestive tract.

- **Down syndrome** is a chromosomal abnormality whereby an individual has an extra copy of chromosome 21 which causes mental retardation, plus physical abnormalities such as respiratory and heart defects.

- **Genetic screening** provides people with information they may need when making choices about having children, eg. women can find out whether they are carriers of some genetic disorders. Gene probes may be used to detect the presence of either the harmful allele or a marker that is closely associated with it.

You will be provided with a range of ethical arguments challenging or supporting the statements below. Sort these arguments into five groups according to the five ethical frameworks provided. The five ethical frameworks listed are:

- Rights and duties
- Maximising the amount of good in the world
- Making decisions for yourself
- Leading a virtuous life
- Christian (moral) values

When you have finished sorting, try to produce at least one additional argument relating to the passage within each framework.
**TASK 2 Using the Ethical Frameworks – Socio-scientific issue – Pre-natal Genetic Screening**

<table>
<thead>
<tr>
<th>Argument</th>
<th>Counter Argument</th>
</tr>
</thead>
<tbody>
<tr>
<td>Every individual, born or unborn, has the right to life.</td>
<td>In a society where the number of children born to most parents is limited by the use of contraception, allowing a child with a genetic disease to be born in effect replaces a healthy child with an unhealthy one. Selecting healthy children will strengthen, rather than weaken, the gene pool, reducing the number of faulty genes in the population.</td>
</tr>
<tr>
<td>Parents may have to make a special commitment of care for a child with a disability. It is up to parents to decide if they are willing and able to do this.</td>
<td>A ‘good’ society is prepared to love and care for individuals irrespective of physical or mental capacities.</td>
</tr>
<tr>
<td>It is unethical to bring a child with a genetic disease into the world if it will result in the suffering of the individual, reduce the happiness of the parents and family, or drain the financial resources of the society.</td>
<td>Rights of a foetus may conflict with rights of the mother if a pregnancy presents risks to the mother’s physical or mental health.</td>
</tr>
<tr>
<td>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.</td>
<td>Medical professionals need to take time and care to explain the full implications of a positive result in pre-natal genetic screening. Unless parents understand the range of potential scenarios, positive and negative, they are not in the position to take the necessary decisions.</td>
</tr>
<tr>
<td>Embryos have the moral status of persons and should not be killed regardless of the extent of the human benefit. Genesis 1:27 states man is made in the image of God.</td>
<td>The ‘Respect for Life’ principle calls us to value and sustain life, other things being equal.</td>
</tr>
</tbody>
</table>
**TASK 2** Using the Ethical Frameworks – Socio-scientific issue – Prenatal Genetic Screening

**Instruction:** Paste the most appropriate arguments in the allocated space.

**FIVE ETHICAL FRAMEWORKS – SSI: Prenatal Genetic Screening**

<table>
<thead>
<tr>
<th>Rights and Duties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximising the amount of good in the world</td>
</tr>
<tr>
<td>Making decisions for yourself</td>
</tr>
<tr>
<td>Leading a virtuous life</td>
</tr>
<tr>
<td>Pluralism/Religious/Faith/Value</td>
</tr>
</tbody>
</table>

Your argument:
Using the Ethical Frameworks – Socio-scientific issue – Genetically Modified Food

LESSON OBJECTIVE

_task_1_ – Students can identify issues related to a specific socio-scientific issue (eg. genetically modified food) and integrate ideas related to these issues in a concept map.

_task_2_ – Students can use the ethical frameworks to reason and argue for the decision made in relation to a specific socio-scientific issue.

AUSTRALIAN CURRICULUM STANDARDS/OUTCOMES

**Year 9/10 Science as a Human Endeavour Strand**

**Nature and Development of Science**

- Scientific understandings, including models and theories, are contestable and refined over time through a process of review by the scientific community
- Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries

**Use and Influence of Science**

- People can use scientific knowledge to evaluate whether they should accept claims, explanations or predictions
- Advances in science and emerging sciences and technologies can significantly affect people’s lives including generating career opportunities
- The values and needs of contemporary society can influence the focus of scientific research

**General Capabilities and Cross-curriculum Priorities**

- Critical and creative thinking
- Ethical Behaviour
- Personal and Social Competence

ACTIVITY FOR STUDENTS – Introducing and Implementing the activity

**Recommended Time:** Two 45-minute class periods

**TASK 1** Identifying the issues related to genetically modified food

Brainstorm some of the ethical issues associated with genetically modified food. Draw a concept map/graphic organiser.
**TASK 2** Using the Ethical Frameworks – Socio-scientific issue – Genetically Modified Food

Read the following statements about the ethics of genetically modified food.

**Genetically modified (GM) food** has the potential to provide significant health, agricultural and economic benefits on a wide scale. It offers a solution towards alleviating third-world hunger, improves agronomic traits and provides environmental advantages such as increased sustainability. Yet on the other hand, there are concerns about risk of cross-pollination, risk of transfer of herbicide resistance and the impact of patents on small farming practices in developing agricultural communities. Objections to the GM technology and its inherent risks also include tampering with the divine order of things, and a feat that genetic knowledge or power will remain in the hands of an elite few. Is GM food beneficial for all communities to use, or is it also useful for some who have the means to manage the risks and address effectively the concerns arising from this technology?

**Glossary Terms**

- **Agronomic traits** are characteristics of plants that are cultivated in large amounts, and examined in relation to its yield (production) and sensitivity to factors such as climate and soil.

- **Cross-pollination** can occur between conventional crops and genetically modified crops. Pollen, carrying the modified gene from a GM crop, could spread to a related, conventional crop by the wind or insects.

- **Genetic Modification (GM)** is used to describe a biological substance that has changed a genetic component by molecular technology to suit specific needs. For example, crops such as potato, canola, corn and maize as well as cotton have been processed to become tolerant to a commonly used herbicide called glyphosate.

- **Herbal resistance** is a characteristic where crops can tolerate higher than normal dose of herbicide. In most cases, the herbicide resistance characteristic comes from bacteria. Examples of herbicide tolerant crops include canola, cotton, tomatoes, potatoes, corn, sugar beet and rice.

- **Patent** is the conferring of exclusive rights to make, use or sell an invention for a specified period of time. There is concern that farmers, especially in developing countries, may be disadvantaged by not being able to save seed for planting, or by losing the benefits of the biological diversity in their own country.
You will be provided with a range of ethical arguments challenging or supporting the statements below. Sort these arguments into five groups according to the five ethical frameworks provided. The five ethical frameworks listed are:

- Rights and duties
- Maximising the amount of good in the world
- Making decisions for yourself
- Leading a virtuous life
- Christian (moral) values

When you have finished sorting, try to produce at least one additional argument relating to the passage within each framework.

**TASK 2 Using the Ethical Frameworks – Socio-scientific issue – Genetically Modified Food**

<table>
<thead>
<tr>
<th>The possibility of undesirable effects resulting from GM does not mean that GM should be morally condemned and banned. There is a place for political and legislative measures to be put into place and to regulate the genetic modification.</th>
<th>Genetically Modified Food as a technology alleviates human suffering such as world hunger.</th>
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<tr>
<td>The idea is that genetic engineering can help overcome genetic defects caused by harmful mutations. In this way, the nature of things can be improved and creations restored.</td>
<td>The benefits far outweigh the risks involved in genetic modified foods.</td>
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<td>To constrain production in a world of hunger is wrong, even immoral.</td>
<td>Genetic modification is practising responsible stewardship – to subdue the world to benefit mankind.</td>
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<td>One must weigh the cost and benefits to produce a clear ethical decision.</td>
<td>Based on fundamental value judgements, one ought to act so that institutions which profit from new technology must seek to minimise losses of the weaker economies and more vulnerable individuals.</td>
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<td>What God has made is inherently good, do not tamper with nature.</td>
<td>One must advocate a careful, well-regulated, step-by-step approach as the most responsible way forward.</td>
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**TASK 2** Using the Ethical Frameworks – Socio-scientific issue – Genetically Modified Food

**Instruction:** Paste the most appropriate arguments in the allocated space.

**FIVE ETHICAL FRAMEWORKS: Socio-scientific issue: Genetically Modified Food**

<table>
<thead>
<tr>
<th>Framework</th>
<th>Your argument</th>
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<tbody>
<tr>
<td>Rights and Duties</td>
<td>Maximising the amount of good in the world</td>
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<td>Making decisions for yourself</td>
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<td>Leading a virtuous life</td>
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<td>Pluralism/Religious/Faith/Value</td>
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Reference (Ethical Frameworks)


Classroom Teaching Strategies in Bioethics Education is valuable in that it addresses some of the main concerns raised in socio-scientific education on the need to develop critical thinking strategies with its emphasis on both the affective and the cognitive aspects of science learning. It reinforces an aspect of science education in training scientifically literate individuals to confront, argue, reason, negotiate and make decisions in everyday situations that involve science. Among the teaching strategies commonly used; namely debates, role-play, discussions and uses of media resources, the use of ethical frameworks is highlighted here as one of several viable working tools that can be used to fulfil the outcome of the Science as a Human Endeavour strand in implementing the Australian science curriculum in the middle school years.

“As stated in this book, there has been an increasing interest in teaching science content in relation to socially relevant life situations that require students to make ethical decisions. Despite this growing interest there is a lack of teaching and learning materials on this topic. Thus, this book makes a valuable contribution towards overcoming this by providing a book containing both teaching and learning materials. The author has effectively researched the area and has used this knowledge in writing a book that begins with a description of the research-based theoretical underpinnings before moving on to practical activities that teachers can use. These activities will be of great value to teachers wanting to become involved in promoting ethical thinking and reasoning in their science classes.”

Professor Darrell Fisher, Professor of Science Education, Curtin University

About the author

Siew Fong Yap, Ph D, is the Head of Science at Kingsway Christian College. Her main research interest is in the area of bioethics and values education with special reference to adolescents’ ethical thinking, reasoning, argumentation and decision making skills in relation to science literacy. She has also written science resource books, contributed to journal publications, conducted professional development workshops on the implementation of the Australian science curriculum as well as presented papers at state, national and international science conferences.