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Cover Page Footnote

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Abstract

As science progresses, new techniques and additional information present society with new situations that require ethical analysis and judgement. More than ever before educators of today face the challenge of preparing students with the knowledge and skills necessary to engage with these issues. This paper explores the potential of the Socioscientific Issues framework for the teaching of ethical understanding within the science classroom of Christian or other faith based schools and offers some insights into what teaching with socioscientific perspective might look like in the classroom.

> *Decisions about genetically modified food, climate change and conservation … will require … [students] to be fluent in the science and the ethics of these issues.*

Two significant announcements in the field of biology marked the commencement and completion of my undergraduate studies. In late February 1996 researchers at the Roslin Institute announced that they had successfully cloned a sheep, which they named Dolly, from an adult cell using a technique called somatic cell nuclear transfer (SCNT). Five years later I recall sitting in the library reading the February edition of Nature that marked the completion of the first draft of the Human Genome Project. It seemed to me then, as it still does now, that these two events would not only create a paradigm shift in the way we approach modern biology, but would forever shift the ethical landscape which scientists and laypeople alike, must negotiate. It is not that there was no ethical issue before Dolly and the Human genome project. Medical issues involving the beginning and ending of human life presented ethical dilemmas then and continue to do so today. However, with these two announcements the knowledge concerning how to genetically alter a human life was thrown wide open.

The reality that our students face today is a world where the genetic screening of embryos for genetic disorders and gender selection is not only possible but routine, to the extent that The National Health and Medical Research Council (2007) developed guidelines for its use. Increasingly couples will be looking to the growing range of artificial reproductive technologies, all of which to varying degrees involve ethical decisions. To make such decisions wisely students will need to be taught both an understanding of the science involved and the skills of ethical decision making, a task for which Driver, Newton, and Osborne (2000) suggest teachers are not well prepared. Indeed, the scope of ethical issues requiring an understanding of science goes much further than that involving fertility and the beginning of life. Decisions about genetically modified food, climate change and conservation, both in the private and public spheres, will require the young men and women that populate our schools today to be simultaneously fluent in the science and the ethics of these issues.

The words ethics and morals are often used interchangeably, particularly in general parlance, however they do have different but interrelated meanings. Morals are the beliefs of a group or an individual that provides general principles about what is right and wrong while ethics is a response to a specific issue and provides a set of guidelines or procedures to help determine what action should be taken in a given situation. Although these differences are not critical to the understanding of this paper the two terms are used here with the intention of maintaining their separate definitions.

To most effectively guide students into the necessary understanding and skills required to confront these present and future challenges it is appropriate to utilize an effective teaching framework that is grounded in research and which is also able to incorporate a distinctive Christian worldview. The Socioscientific Issues movement is capable of fulfilling both of these requirements.

It is the purpose of this paper to introduce this framework as a useful tool for science educators working within a faith based tradition.

Teaching ethics in the science classroom

Adventists educators in the field of science have always recognised the opportunities inherent in the teaching of science for the exploration of Christian worldviews. Unfortunately, for many science educators, this has been limited to the broader issues surrounding the origins debate. It is the belief of the author that such a narrowing of focus misses some of the greatest opportunities we have in the science classroom for exploring what it means to be a Christian in the modern world. There are countless issues across all fields of science that require ethical judgments to be made about current and engaging topics. The process of ethical decision making by which students, and indeed all individuals, come to conclusions about these issues is a direct result of the individual's worldview. It should be clear then that a discussion about ethics is a direct link for educators into a discussion about how ethical decisions are made and the role of religious faith in those decisions.

The importance of ethical thinking and ethical thinking practices was recognized by the writers of the Australian curriculum (The Australian Curriculum Assessment and Reporting Authority (ACARA), n. d.) which incorporates ethical thinking as one of the cross-curriculum priorities.

> In the Australian Curriculum, students develop ethical understanding as they identify and investigate the nature of ethical concepts, values and character traits, and understand how reasoning can assist ethical judgment. Ethical understanding involves students in building a strong personal and socially oriented ethical outlook that helps them to manage context, conflict and uncertainty, and to develop an awareness of the influence that their values and behaviour have on others.
>
> (para. 1)

If the Australian Curriculum is to be taken seriously then within the context of ethical understanding it provides a mandate for faith based schools to explore the role of their religious traditions across all subjects, including that of science.

Within Adventist schools across Melbourne, Pope (2014) has shown that a disconnect exists between students' reported religious beliefs and their ability to incorporate those beliefs into their ethical reasoning about biotechnology issues. In this study, the first to explore socioscientific issues in Adventist schools, the author was able to show that considerably fewer students use religious ideas in their reasoning than were identified as measuring high on a scale of Christian worldview. When they did incorporate religious ideas into their reasoning, the students rarely incorporated rational reasoning involving faith-based principles. Instead, most students would make vague references to religious belief or God, if they made any reference at all, with comments of the kind, 'it's against Gods will' and 'this goes against my religion'.

Such a lack of clarity between the students' religious beliefs and their informal reasoning is not necessarily surprising. Moral values and attitudes can ultimately be traced back to an individual's worldview and teachers might expect that students with Christian worldviews would naturally incorporate their beliefs into their moral judgements. However, most individuals do not stop to closely examine their worldview, which may direct the decisions and attitudes of an individual without the student's conscious awareness of the fact (Evensen, Hoban, & Woodrum, 2000). Although the expectation that students will be able to provide moral arguments that are able to offer clarity to their worldview may currently remain unmet, the deliberate teaching of ethical reasoning skills in the science classroom through the use of controversial issues provides an opportunity not only to fulfil the expectations of the Australian Curriculum, but also for the examination and transformation of worldviews. Cobern (1997) has suggested that it is the latter that should be one of the primary goals of education.

"a disconnect exists between students' reported religious beliefs and their ability to incorporate those beliefs into their ethical reasoning about bio-technology issues."

Introduction to socioscientific issues

Socioscientific Issues refers to both an educational movement and also a description of the particular type of issue that the movement utilises. Socioscientific Issues are issues that arise as a result of scientific endeavours, or in which science plays an important role and also contain elements that have a strong social context. Such issues are frequently controversial in nature with strong competing values and interests. They can be politically sensitive and often promote powerful emotions amongst the protagonists. These controversial issues are inevitably complex and their consideration may require specific scientific knowledge, awareness of self and a sense of identity. To make sense of such issues typically requires the balancing of ideas, the disclosure of pre-conceived assumptions, and taking a stance while accepting the differing views of others. Given the nature of these issues it should be clear that they are ideal for the exploration and interaction of worldviews, including Christian worldviews in the study of science.

The *Socioscientific Issues* movement

emphasises the need for science education to incorporate the holistic development of individuals. In a critical review of the literature, Zeidler, Sadler, Simmons, and Howes (2005) argue "that any view of functional scientific literacy falls short of the mark if it ignores the fundamental factors aimed at promoting the personal cognitive and moral development of students" (p. 362).

Through the use of controversial issues in science, the *Socioscientific Issues* movement provides an ideal basis from which to teach science and to research the teaching of science from within a faith based tradition.

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Historical Development and Scope of SSI

Science educators have long realised the need for students to understand the interrelationship that exists between science and society with research and dialogue in this area taking place for as long as the field of science education has been in existence (DeBoer, 1991). Gallagher (1971) was one of the first to highlight the importance of placing scientific knowledge within a social construct and since then ongoing research has continued to highlight the importance of this interaction between science and society in developing students' scientific literacy. Leading up to the 1980s, an effort was made to make science more relevant and appropriate to students. To achieve this end, a number of science courses and programs began including material that placed science in a social context in an effort to make science more socially and culturally relevant to students. In a review of the curriculum material then available, Ziman (1980) coined the term Science-Technology-Society (STS). The STS movement grew quickly during the 1980s, both in its popularity with science teachers and as a theoretical framework for teaching science. STS is essentially a method of teaching science that places the context of the issues as a central theme that can then be used as a mechanism for teaching not only science concepts but also the process of scientific inquiry (Yager, 1993). It was adopted by the National Science Teachers Association (1982) as a central goal for science education, stating that:

> The goal of science education during the 1980s is to develop scientifically literate individuals who understand how science, technology and society influence one another and who are able to use their knowledge in their everyday decision making. (p. 1)

Throughout the 1990s, the enthusiasm for STS started to wane with science educators such as Shamos (1995) noting that the movement did not fulfil its purpose of being exciting and relevant to students. Moreover, Zeidler et al. (2005) identified that the STS movement had failed to give students a voice about the issues being examined, nor did it did allow for students to approach those issues from a personal perspective, grounded in the cultural background of the students. Zeidler et al. (2005) further suggested that STS, which lacked a grounded theoretical framework, did not provide for the moral or character development of the students. In what has largely been seen as a successful reinterpretation of the STS model, an additional dimension that includes the beliefs and life experiences of students was added to the STS framework (Zeidler et al., 2005). This reworking of the STS framework was titled socioscientific issues (SSI) and its main aim as a movement is to focus "specifically on empowering students to consider how science-based issues and the decisions made concerning them reflect, in part, the moral principles and qualities of virtue that encompass their own lives, as well as the physical and social world around them" (Zeidler et al., 2005, p. 360).

In a discussion about balancing the sometimes conflicting concerns and desires of the individual stakeholders associated with socioscientific issues, Kolstø (2006) outlines the underlying tensions that dominate much of the debate about these issues:

> Because we have different wishes, values, and beliefs, society is loaded with these sorts of conflicts. Such conflicts cannot be solved by means of value-free evaluations or calculations, but have to be negotiated; therefore, we need politics and discussion to weigh values that in principle cannot be weighed. (p. 298)

Kolstø's comment highlights one of the important differences between SSI and earlier attempts to incorporate society and science. Central to the SSI movement is the goal to provide students with the skills necessary for them to negotiate for themselves the science-based issues that they will inevitably be confronted with, if not at a personal level, then as a member of society that will be called upon to make judgements on the technologies (Driver et al., 2000; Kolstø, 2006). Socioscientific issues cover a broad range of topics; some of the examples of SSI's that have been studied in the literature include the applications of biotechnology (Pope, 2014; Sadler & Zeidler, 2005), climate change (Topçu, Yılmaz, & Sadler, 2011), nuclear power (Wu & Tsai, 2007) and other more local issues such as the reintroduction of bears into the Pyrenees (Simonneaux & Simonneaux, 2009).

Educational Benefits of SSI

The educational benefits of an SSI-based approach

to teaching science have been widely recognised by researchers in this field (Levinson, 2006; Zeidler & Sadler, 2008). Just some of the reasons for implementing an SSI approach include positive impacts on science instruction (Barab, Sadler, Heiselt, Hickey, & Zuiker, 2010), increased understanding of science content (Zohar & Nemet, 2002), improved argumentation skills (Venville & Dawson, 2010), and increased understanding of the nature of science (Khishfe & Lederman, 2006).

In addition, Fowler, Zeidler, and Sadler (2008) have shown that the use of a Socioscientific Issues framework can improve students' moral reasoning skills about controversial issues. Leaders in the field of Socioscientific Issues (Zeidler et al., 2005) have suggested that SSI creates cognitive dissonance by compelling students to consider claims that may be at odds with their own beliefs and values. It is thought that this may advance moral reasoning by empowering students to consider how science based issues and the decisions made concerning them reflect, in part, the moral principles and qualities of virtue that encompass their own lives, as well as the physical and social world around them.

A number of researchers and commentators have called for science education to better equip students in their ability to undertake the task of negotiating the ethical issues associated with biotechnology. These calls have come from science professionals and science educators, as well as religious leaders. Polkinghorne (2000), an accomplished scientist (FRS) and an ordained Anglican priest, commented that:

> It is important that society should seek to create forums in which ethical issues can be discussed in truth-seeking and non-confrontational manner. If this prospect of rational debate about biotechnology is to be realised, a considerable educational program will be required. (p.10)

Science education programs that use the socioscientific framework are ideally suited to provide the educational program necessary for students to negotiate the ethically complex world that advances in science will present to them. For students who come from a Christian religious upbringing or whose own worldview is dominated by a religious faith, teaching science using a Socioscientific Issues framework provides the possibility for students to approach controversial issues in an environment that acknowledges their core beliefs and recognises that those beliefs will help to shape opinion and behaviour about controversial issues in science.

Using a Socioscientific Issues Framework in the classroom

A number of researchers agree that one of the primary purposes of education is to provide an opportunity for the examination and transformation of worldviews (Cobern, 1996, 1997; Duschl, 1991; Peters, 1975). Because of the way that the socioscientific issues movement draws upon culture, including a religious understanding of controversial issues in science, it provides an opportunity for students to examine the presuppositions and cultural norms that are inherent in their worldview. As SSI's are explored, the interactions that an individual has between their peers, their teachers, and the wider community may play an important role in shaping an individual's worldview. The power of social interactions in shaping an individual worldview is emphasised by Haidt (2001):

> Because people are highly attuned to the emergence of group norms, the model proposes that the mere fact that friends, allies, and acquaintances have made a moral judgment exerts a direct influence on others, even if no reasoned persuasion is used. Such social forces may elicit only outward conformity, but in many cases people's privately held judgments are directly shaped by the judgments of others. (p. 7)

"An appreciation of the role that formal schooling can have in shaping a student's worldview should give science educators reason to pause."

An appreciation of the role that formal schooling can have in shaping a student's worldview should give science educators reason to pause. As figures of authority within the classroom, there is significant opportunity to influence the development of a students' worldview; however, this also comes with a responsibility to respect the cultural values of the group so as to minimise the harm that dissonance within the students' worldview may bring.

Due to the nature of socioscientific issues, it is likely that two students may come to opposing conclusions about a particular issue, such conclusions are ultimately moral judgements that are the result of conscious thought and that reflect the individual's notion of right and wrong (Haidt, 2001). Through sound reasoning and the use of established ethical frameworks, general consensus and confidence in an ethical decision can be established (Reiss, 1999),

Research by Saunders (2009) and Yap (2012) have demonstrated the usefulness of ethical frameworks for teaching socioscientific issues. These two researchers used ethical frameworks, such as rights and duties, utilitarianism, autonomy, and virtue ethics, to guide students in their ability to critically reflect and analyse socioscientific issues and to make rational decisions that reflect their own ethical values. When combined with teacher

role-modelling of scientific reasoning, and through the creation of a collaborative and caring learning environment, the use of ethical frameworks can be a valuable strategy for teaching controversial issues in science (Reiss, 2008; Yap, 2012). Further to this, Saunders (2009) developed a model for ethical inquiry that incorporated ethical frameworks and which was successfully used to support science educators by providing them with a structural basis from which a unit of work involving ethical inquiry could be developed.

"The development of an open and non-threatening environment is … a high priority when using a socio-scientific framework in the classroom."

Reflections and strategies of a Science educator using Socioscientific Issues

As an active science classroom teacher, the author has utilised a number of strategies to effectively teach using the socioscientific framework including: maintaining an open and non-threatening environment, prior presentation of core knowledge, the use of debates and role playing, ethical frameworks, and media analysis. A consideration of each strategy follows.

Open and non-threatening environment

In any discussion about controversial issues it is important that students know that their views will be respected by both the teacher and the other students, otherwise they will be unwilling to share their views with the class. The development of an open and non-threatening environment is therefore a high priority when using a socioscientific framework in the classroom. Any open discussion about controversial issues needs to be bracketed with a clear statement made by the teacher asking students to respect the diverse views of the individuals within the class. Managing a group discussion about controversial topics is not necessarily an easy task for educators to implement with confidence (Osborne, Duschl & Fairbrother, 2002), for as Levinson (2004) points out, "science teachers tend to take an 'authoritative-non-dialogic approach" (p. 367).

Teachers may first need to develop the trust of their students by starting with less emotionally sensitive issues, such as the use of wind turbines, before approaching more divisive issues like those that require an examination of genetically modified organisms or Preimplantation Genetic Screening (PGS). It is also helpful for the students to see that the teacher is willing to show vulnerability by sharing their own views and the reasons for them. Such disclosure must of course be done with humility and caution so as not to place the teachers view as 'the right conclusion', but rather that of another voice in the debate. Ultimately the individual teacher must develop the skills of guiding classroom discourse that respects the differing views of the students while still gently forcing them to question and analyse the presuppositions and ethical decision making that brought them to a conclusion about the issue being examined.

Understanding of the science behind the issue

While Sadler and Zeidler (2005) have shown that content knowledge may have a limited influence on students' final decision making about controversial issues in science, an appropriate level of scientific understanding is necessary for students to understand the issue and engage with the topic using appropriate ideas and terminology. A useful activity is to pre-poll students' opinions about a socioscientific issue and then get them to revisit the issue after learning more about the topic. This provides students with an opportunity to reflect on how understanding the science may have modified their ethical thinking.

Debates and role playing

The use of debates has a long tradition in teaching and this technique of exploring socioscientific issues is useful as it forces students to understand the topic and present an argument from a position that they may disagree with. An alternative method to achieve similar results is the use of role playing using the ABC's Q&A approach. In this example five to ten students would be given the fictional biography of a stakeholder in the issue being examined. While the audience (the rest of the class) asks questions of the panel each panel member must reply from the perspective of the biography they were provided with, all controlled by the teacher acting as moderator of the panel. This approach is in tune with the socioscientific framework and the Australian curriculum which calls upon students to examine issues from the perspective of other community members. Such panels can be both fun and insightful for the students, however it does require time for the students to research how a particular community member might feel about different issues. This is best done as a group with one member stepping up to join the panel and the remainder joining the 'audience'.

Ethical frameworks

Depending on the year level of students involved a number of different ethical frameworks can be explored. The typical pedagogy of the author is to present these ethical frameworks with a short definition and explanation, a description of the strengths and weaknesses of each, followed by a series of guiding questions that are important to that particular ethical framework. Table 1 describes

the ethical frameworks and the guiding questions typically used by the author. Most of these definitions and guiding questions were initially developed by The New Zealand Biotechnology Learning Hub (2011) which also provides a range of quality online resources for teaching ethical reasoning within a science context (http://biotechlearn.org.nz/). The definition and questions for the Christian ethical framework were adapted from a study guide produced by Gowing (2011) for the Australian Fellowship of Evangelical Students.

The development of a specific Christian ethical

Table 1: Ethical Frameworks and guiding questions

Ethical Framework	Guiding questions
Deontological Ethics What is right and wrong is what some authority says is right and wrong. This authority is sometimes referred to as the 'Ultimate reality' or 'God', but could be the laws or rules in a community.	Who or what has authority? How can the authority's will be known? What is the authority's will in this matter? (provide evidence) Who or what is under this authority?
*Consequentialism** Weigh the benefits and harms resulting from our actions. Egoism: good for me Altruism: Good for someone else Utilitarianism: The most good for the most people.	Who or what is affected by this issue? What are the possible benefits for those affected? What are the possible harms for those affected? Which option(s) will produce the most good and the least harm? If one is harmed and another benefits, how do you decide who or what matters most?
*Rights and Responsibilities** Rights and Responsibilities are closely related: the rights of one imply the responsibilities (or duties) of another to ensure those rights.	Who/what is affected by this issue? Which groups have rights associated with this issue? What are their rights? Do these same groups also have responsibilities? What are their responsibilities? Do we value some rights more than others? Whose rights do we want to protect? Do any codes, declarations and/or conventions relate to this issue?
*Autonomy** Autonomy recognises the right to choose for yourself.	Who/what is affected by this issue? What effects might my choice have on others? What effects might others' choices have on me? Does everyone have to do the same thing? Will this cause problems? What is informed consent? Is it important here?
*Virtue ethics** A virtue is something that the community accepts as being 'good', such as honesty, kindness and patience. Virtue ethics emphasise decisions that are in line with these characteristics.	Who/what is affected by this issue? What qualities make someone a 'good' or virtuous person? What decisions/actions in relation to this issue would make you a 'good' person? What people would agree that these decisions/actions are 'good'? What people would disagree that these decisions/actions are 'good'?
*Christian Ethics*** "He has shown you, O mortal, what is good. And what does the Lord require of you?To act justly and to love mercy and to walk humbly with your God." Micah 6:8 (NIV) To determine what is 'good' or loving in a given situation, we must remember to seek the goal of mutually loving relationships. The Christian ethical principle should always be one of mutually loving relationships.	What are the relationships? What are the obligations to those relationships? What understandings and reflections do we have from the Bible? Are the situations directly addressed in the Bible? If they are not addressed in the Bible, what are the areas of theology that impact our thinking about the issue?

*Definitions and guiding questions adapted from Using Ethical Frameworks in the Classroom (The New Zealand Biotechnology Learning Hub, 2011)
**Definitions and guiding questions adapted from Developing a Christian Ethic (Gowing, 2011, p. 15).

> *"He has shown you, O mortal, what is good. And what does the Lord require of you? To act justly and to love mercy and to walk humbly with your God"*

framework is problematic as the range of approaches to Christian ethics is as broad as the range of beliefs within Christian theology. It is the opinion of the author that a Christian ethic is expressed in the choice of ethical frameworks that are selected for a given issue and the decisions made whilst implementing those frameworks. Nevertheless, a Christian ethical framework based on 'Micah 6:8' has been included and provides a useful starting point for exploring a specific Christian ethical framework.

Students should be encouraged to utilise a range of different ethical frameworks, as some issues are better navigated with one framework than with another. Students can be asked to justify their decision to use the selected framework as well as attempt counter arguments using the same or a different framework, possibly from a different cultural or religious perspective. As the students become more proficient in using ethical frameworks the beliefs embedded in their worldview naturally start to reveal themselves. With appropriate questioning and discussion these beliefs can be drawn out, examined and compared with the beliefs of others in the classroom.

"Students should be encouraged to utilise a range of different ethical frameworks, as some issues are better navigated with one framework than with another."

Media analysis

The use of a media article from a newspaper, magazine, blog or news broadcast can be an engaging way for students to explore socioscientific issues. Careful selection of the media article, which could be written or multimodal, is required. Some consideration should be given to the length of the article, if too short it may lack the detail necessary for students to gain an appreciation of the issue, if too long the student may get bored or distracted by unnecessary detail. The article must also be at an appropriate reading age and be free of unfamiliar jargon and concepts that may limit the reader's ability to comprehend the issue being addressed. Typically, a student would be asked to identify and summarise the main ethical contentions in the article, identify who or what is affected by this issue and then utilise an ethical framework to make an argument outlining their opinions about the issue. When students are familiar with a range of ethical frameworks they can be directed to use a specific framework to argue for a given position on the issue. As an extension, the students understanding of ethical frameworks can be further tested by asking them to identify any biases in the reporting and the ethical frameworks utilised by the author of the media article. Discussions about why the author may have selected a specific ethical framework and whether it has been appropriately and convincingly used may provide students with an insight into their own and their classmates' worldview.

Conclusion

The implementation of SSI into the science curriculum is not without some challenges, however there is also much to be gained. To appropriately address socioscientific issues many science teachers will need to gain a better understanding of ethics and ethical arguments. Teachers may also lack the skills to teach ethical issues (Driver et al., 2000; Levinson, 2004), including how to manage classroom discussion about controversial issues and teach from a worldview perspective. Teaching with an awareness of the worldview of students in the classroom can be challenging as it demands that teachers respect students as thinking individuals, while also exposing students to a variety of alternative modes of explaining, so that students can test their personal views against other views (Proper, Wideen, & Ivany, 1988).

Additional professional development may be required to fill this gap in knowledge and professional practise, however the gains could be significant. Improvement in understanding of science content and the nature of science, along with improvement in argumentation skills and moral reasoning are of significant value, but of greater importance may be the opportunity to explore real world application of the student's faith beliefs and to develop students that have integrity in their ethical decision making such that it is in tune with their religious beliefs. TEACH

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Tim Pope asserts he is "imbedded" primarily in the world of secondary education [as a secondary teacher and administrator] but confides academic research remains a small, if not passionate, pastime. This article emerges from reflections upon his doctoral research studies that were conducted through Curtin University while in full time employment. He continues to challenge students' to resolve emerging ethical conflicts within current issues with informed understanding of their worldview. He invites colleagues into a dialogue about further developing classroom strategies and theoretical perceptions in this area.

> *"of greater importance may be the opportunity to explore real world application of the student's faith beliefs and to develop students that have integrity in their ethical decision making"*