Effect of religious belief on informal reasoning about biotechnology issues

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The advances of modern biotechnology provide teachers with a number of opportunities to explore socioscientific issues, and in doing so to enhance students' reasoning skills. Although some attempt has been made to understand cultural differences in students' informal reasoning across international and regional boundaries, there is limited research about the differences that exist between students who identify with a Christian worldview and those students who do not. To investigate the role that students' religious beliefs played in their informal reasoning about biotechnology issues regarding genetically modified food, genetic screening, therapeutic cloning and reproductive cloning, the written responses of 101 students identified as accepting a Christian worldview was compared with 21 students who did not identify with a Christian worldview. Using a qualitative approach, the students' responses to these issues were analysed to identify the modes of informal reasoning incorporated in the justification of their views about the technology. It was shown that students with a higher degree of religious belief demonstrated less use of rational reasoning and a greater reliance on intuitive reasoning in their responses to socioscientific issues when compared with their less-religious peers. The findings highlight the need for initiatives that will develop students' rational and emotive reasoning and encourage them to acknowledge the presuppositions of their belief system and how these influence their attitudes towards controversial issues in science.

INTRODUCTION

In recent years, there has been an inclusion in the Australian secondary school science curricula of issues that arise from science that are considered controversial in nature. An example from the Australian science curriculum, (ACARA, 2016) calls for students to examine how:

> Advances in science and emerging sciences and technologies can significantly affect people's lives. … [while] investigating the applications of gene technologies such as gene therapy and genetic engineering [ACSHE195 (ACARA, 2016)].

The Australian science curriculum identifies the need for students to understand the combined role of scientific, ethical, economic and social arguments in decisions regarding personal and community issues [ACSIS206 (ACARA, 2016)]. An appreciation that science needs to be studied within a social context was becoming evident when Gallagher, (1971) commented that:

> For future citizens in a democratic society, understanding the interrelationships of science, technology and society may be as important as understanding the concepts and processes of science (p 337).

Recognition that science needs to be placed within a broader social context gave birth to the science, technology and society movement as a strategy to address the interface between science and society. More recently, a new framework for exploring the interplay between science and societal issues, the socioscientific (SSI) movement, has been developed centring on students' personal, cognitive and moral development (Sadler & Dawson, 2012). SSI are broadly defined in the literature as socially relevant issues, often associated with controversy and social debate, which result from the products or the processes of science (Fleming, 1986; Sadler & Zeidler, 2004, 2005).

Because SSI are controversial in their nature, they are often difficult for students to resolve. The thinking that a student does in an attempt to resolve such issues is termed 'informal reasoning' and incorporates both the cognitive and affective processes used by the students (Means & Voss, 1996; Sadler & Zeidler, 2005; Zeidler, Sadler, Simmons, & Howes, 2005). Sadler & Zeidler (2005) identified three 'patterns of informal reasoning' that individuals utilise in their attempt to resolve these issues.

1. Rationalistic reasoning: utilising reason-based considerations.
2. Emotive reasoning: utilising empathy- and sympathy-based considerations.
3. Intuitive reasoning: unexplainable immediate reactions.

The use of informal reasoning by students represents an important aspect of students' decision-making processes about SSI (Kuhn, 1993), and consequentially the classroom discourse that takes place regarding SSI. What a student ends up concluding about the merits or appropriateness regarding the use of biotechnology comes out of the student's worldview, which includes the individual's beliefs, such as beliefs about biotechnology, religious beliefs, and other beliefs (including, but not limited to, normative beliefs and gender beliefs). From these beliefs comes a student's attitude about biotechnology and, ultimately, their intentions and behaviour. This process of moving from beliefs, sometimes consciously held and sometimes not, to intentions and behaviour is encapsulated in the process of informal reasoning. In this context then, informal reasoning can be described as the thought process that a student undergoes as they move from worldview to behaviour.

Science educators have highlighted that the development of students' scientific literacy would benefit from in-depth interactions between students from a range of cultural viewpoints (Aikenhead, 1985; Driver, Newton, & Osborne, 2000; Vellom & Anderson, 1999). A small number of studies have examined students' informal reasoning through different cultural lenses: Topçu's study involving Turkish preservice science teachers (Topçu, Yilmaz, & Sadler, 2011), a study from Taiwan involving high school students (Wu & Tsai, 2007), two Australian studies also involving high school students (Dawson & Venville, 2009; Yap, 2012), and a US study (Sadler & Zeidler, 2005) involving college students. However, cultural diversity also exists within a school setting and one of the more obvious differences amongst secondary students is religious identity. Despite a comprehensive search of the available literature, no studies that compared the informal reasoning of students from the cultural perspective of the Christian faith have been identified. It is anticipated that an understanding of how the religious beliefs of students impact on their informal reasoning will contribute to the growing field of research that will enable teachers to be better prepared for discussions about SSI in their classroom.

The aim of this research was to determine whether there was any difference in informal reasoning patterns about biotechnology applications of upper secondary school students (aged 16–18 years) with high or low religious beliefs.

METHOD

DATA SOURCE

To discern the differences in patterns of informal reasoning between students with differing religious worldviews, questionnaire data was collected from Australian senior secondary students from three faith-based schools. Students were requested to complete the Christian Worldview Scale (CWS) and respond to four biotechnology issues as part of a larger study on students' attitudes towards biotechnology. The CWS is a comprehensive assessment of students' religious beliefs collated by Pope (2014) that incorporates aspects about core doctrinal beliefs (orthodoxy), religious behaviour, and scriptural literalism as a

proxy for Christian fundamentalism (Hill & Hood, 1999; Hunsberger, 1989; Jennings, 1972; Rohrbaugh & Jessor, 1975). There are 25 items in a Likert-style survey. Data collected from the CWS was used to differentiate students into low and high levels of religious belief. Those students who scored midway on the CWS were removed from the sample to provide a clearer distinction between the two groups and to eliminate as much as possible from the sample those students who may have had a religious but non-Christian worldview. After consideration of the CWS, the cut-off scores for high and low levels of religious belief were selected such that, while students with a nominal non-religious worldview may have been included with the low religious belief group, students with a high level of religious but non-Christian belief—such as students from an Islamic or Hindu background—should be eliminated from the analysis. The resulting sample consisted of a total of 122 students, including 21 with a low level of religious belief and 101 with a high level of religious belief.

In order to explore students' informal reasoning about SSI, students were asked to state whether they agreed or disagreed with the use of four separate biotechnologies and to list reasons to justify their decision. The questions were adapted from Sadler and Zeidler (2005) and are presented as ethical dilemmas about biotechnology applications. The applications were: genetically modified food (GM food), pre-implantation genetic screening (PGS), therapeutic cloning (T. Clone), and reproductive cloning (R. Clone). Each of these questions is associated with complex social and scientific issues and none have simple answers that can be approached in a purely deductive manner. Instead, these four ethical dilemmas require students to utilise informal reasoning as they come to a decision about their personal stance on each of these SSI.

DATA ANALYSIS

To examine how the acceptance of a Christian religious belief may affect students' informal reasoning, the written responses to the ethical dilemmas were analysed and coded according to the type of informal reasoning identified. For the purpose of this study, a 'statement' referred to one sentence or phrase made by the student that was identified and coded as rational, emotive, or intuitive. A 'comment' refers to a student's complete answer to one ethical dilemma and the term 'response' is used to describe all of the written material made by a student. Because some students did not complete all sections of the survey, the students' responses ranged from one to four comments.

The total number of comments provided by the 122 students was 423, which included 75 comments from the 21 students with a low level of religious belief and 348 comments from the students with a high level of religious belief. The statements for each student were coded according to the mode of informal reasoning identified and reviewed by a researcher familiar with Sadler and Zeidler's (2005) patterns of informal reasoning. No substantive discrepancies were found between the two researchers' codification of the statements, with any minor differences being resolved upon discussion.

RESULTS

An in-depth description of how statements were coded as rational, emotive, or intuitive is provided to ensure a clear understanding of what the three modes of informal reasoning represent. Student comments are labelled with an 'R', 'E' or 'I' to identify the mode of informal reasoning used, along with the identification code of the student.

RATIONALISTIC INFORMAL REASONING

Statements coded as rational informal reasoning were logical, used scientific understanding and language, and weighed up risks and benefits or advantages and disadvantages. The following statements related to the GM food question demonstrate the scientific knowledge and language used by students when undertaking rational informal reasoning.

> The over-reliance on insecticides nowadays will increase the insects' resistance and cause future repercussions, as well as allowing chemical corporates [sic] to take more money out of hard-working farmers for fertilisers/chemicals. (R, 167)
>
> It can help third world countries and it helps keep food prices down but it also is a considerable danger to the future of

> agriculture. It restricts biodiversity and could have an effect on our wildlife that could be devastating. (R, 155)

Both of these students incorporated rational reasoning in providing scientific reasons to support their views about genetically modified food. Student 167 clearly stated what he considered to be the benefits of the technology while student 155 identified both risks and benefits.

Other statements, also classified as rational, provided a simple but logical explanation of the advantages of the technology, as demonstrated by this individual's response to genetic screening: "Getting rid of the diseases before birth may save the child's life". (R, 161)

EMOTIVE INFORMAL REASONING

Emotive informal reasoning was characterised by an emotional response towards stakeholders, with care, empathy, sympathy and concern for the plight of those affected. The following response is an example of a student who explicitly identified a number of the stakeholders and provided an emotive response to their situation.

> Parents would be glad to have a child. But the child might think differently if it knew that he/she was born not from their parents but their clones. (E, 154)

The next two statements show that concern, sympathy and empathy were incorporated into the resolution of these ethical scenarios.

> It is painful for parents to live with a diseased child. (E, 167)

> It's good to give couples a chance to reproduce. (E, 166)

While disagreeing with the use of the technology, some students were still able to show sympathy to those facing these difficult decisions, as this student showed when responding to the dilemma of reproductive cloning.

> Being unable to … have a child would be heartbreaking but I still believe that cloning is wrong. (E, I, 305)

INTUITIVE INFORMAL REASONING

Many students expressed a short statement that appeared to be a 'gut response', one that offered no explanation or logical analysis of the situation. Such statements included "This makes me sick" (I, 337), "Let what happens happen" (I, 333) and many statements that included the phrase 'playing God'.

Some of these students had strongly held beliefs about these issues and this was evident in the intuitive statements they made. The following example provides evidence of this.

> The chances that cloning would be successful are slim and playing with human life is crossing the line. Have we finished stuffing up everything that we just decide that it's OK to play with human life? (I, 409)

While coding the informal reasoning of students, it was observed that, consistent with other studies (Sadler & Zeidler, 2005; Topçu, Sadler, & Yilmaz, 2010; Yap, 2012), students were using some modes of reasoning more often than other modes. The frequencies with which students use informal reasoning is referred to here as the patterns of informal reasoning. To examine how the acceptance of a Christian religious belief may affect students' patterns of informal reasoning, the percentage of students who used rational, emotive and intuitive reasoning in their comments and responses was calculated for the students who scored high on the CWS, and those students who scored low on the same scale. Any individual student may have included one, two or all three modes of informal reasoning, because of this non-independence between the modes of reasoning, it was considered inappropriate to compute inferential statistics to determine differences. Instead, the percentage of students who employed each mode of reasoning at least once, separated according to whether the student scored high or low on the CWS, is presented in Table 1 for each of the four dilemmas.

COMPARISON OF TYPES OF INFORMAL REASONING AND LEVEL OF RELIGIOUS BELIEFS

In comparing the informal reasoning of the high and low levels of religious belief groups, some consistent trends were observed. Students who scored high on the CWS (i.e., high religiosity) employed

rationalistic and emotive reasoning less often than those with a low level of religious belief, and they used intuitive reasoning more frequently than the students who scored low on the CWS. For all but the GM food ethical dilemma, the pattern of informal reasoning was similar for both the high and low religious belief, with intuitive reasoning being the most used, followed by rational reasoning, with emotive reasoning used the least. The GM food dilemma differed in that, for this issue only, students used rational reasoning more frequently than the other two modes and students with a low level of religious belief used emotive reasoning more often than intuitive reasoning.

As observed in Table 1, for each of the four ethical dilemmas, students with a high level of religious belief used less rational reasoning than their less religious peers. The percentage of students with a high level of religious belief who used rational reasoning at least once in their response was 76%, which is far fewer students than the low level of religious belief sample, which had 95% of students using rational reasoning.

Students with a high level of religious belief used less emotive reasoning than either the rational or intuitive modes for each of the dilemmas, when compared to students with a low level of religious belief. Fewer students with a high level of religious belief utilised the emotive mode of informal reasoning in their response, as shown by the total responses in Table 1. Highly religious students who did use emotive reasoning did so less often than their less religious peers, as is indicated by the total comments in Table 1.

Students with a high level of religious belief used more intuitive informal reasoning for three of the ethical dilemmas; genetically modified food, pre-implantation genetic screening and reproductive human cloning. In the therapeutic human cloning dilemma, students with a high level of religious belief used intuitive reasoning less often than those students with a low level of religious belief. The relationship between a high level of religious belief and the increased use of intuitive reasoning is more obvious when the number of responses that utilised each mode of reasoning is considered. Most (91%) of the students with a high level of religious belief used intuitive reasoning at least once in their response, while only 76% of students with a low level of religious belief used intuitive reasoning. Table 1 also shows that the total number of intuitive comments made by students scoring high on the CWS is greater than those students who scored low on that scale, which indicates that not only do more students use intuitive reasoning if they have a high level of religious belief, but they also use intuitive reasoning more frequently than their less religious peers.

Informal Reasoning	GM Food		PGS		R. Clone		T. Clone		Total (Responses)		Total (Comments)	
	Low[a]	High[b]	Low[a]	High[b]	Low[a]	High[b]	Low[a]	High[b]	Low[a]	High[b]	Low[c]	High[d]
Rational	81	70	38	37	33	15	38	33	95	76	53	45
Emotive	19	14	14	9	24	15	14	7	43	34	20	13
Intuitive	14	42	52	73	52	63	43	39	76	91	45	63
No Response	5	3	14	7	10	18	14	26	-	-	12	16

Note. GM Food = Genetically Modified Food; PGS = Pre-implantation Genetic Screening; R. Clone = Reproductive Human Cloning; T. Clone = Therapeutic Human Cloning.

a From the sample of Low Christian religious belief, n = 21 students/responses. b From the sample of High Christian religious belief, n = 101 students/responses. c From the sample of Low Christian religious belief, n = 75 comments. d From the sample of High Christian religious belief, n = 348 comments.

Table 1: Percentage of Comments and Responses Utilising Each Mode of Informal Reasoning for High and Low Religious Belief.

DISCUSSION

While broad trends concerning the patterns of informal reasoning amongst students in this and other studies may be justified, it is not known what priority the students placed on each of the three modes of informal reasoning when making their final decision about a socioscientific issue. As has been shown here, and by others (Dawson & Venville, 2009; Sadler & Zeidler, 2005), more than one mode is often used when negotiating socioscientific issues. It may be that although a student uses intuitive reasoning they are basing their decisions about the biotechnology process on the rational or emotive aspects of their reasoning. However, it is unlikely this is the case, given the research by others (e.g., Evans, 1996; Thompson & Evans, 2012; Wu & Tsai, 2007) which suggests that students may be making decisions about an issue first and then coming up with rational arguments to justify their decision. As well as equipping science teachers with an understanding of the informal reasoning of students holding to Christian worldviews, this study highlights the need for classroom initiatives that encourage the increased use of rational and emotive reasoning.

The limited use of emotive reasoning by students measuring high on the CWS is noteworthy given the Christian tradition of care and empathy. It is often assumed that, because of the biblical notions of 'love your neighbour' and 'the Good Samaritan', religiosity would correlate positively with measures of empathy and care. If one assumes that a student who demonstrates a greater degree of empathy would also be more inclined to engage in emotive reasoning—although no such connection was investigated in this study—it could be hypothesised that those individuals who recorded a greater level of Christian belief should correspondingly demonstrate a greater reliance on emotive reasoning. This study found no evidence for such a conclusion. While some evidence suggests that adolescent religiosity is positively correlated with empathy, it is possible that an individual's attitude and approach to religion may be a better predictor of measures of empathy and emotional intelligence than religiosity itself (Duriez, 2004; Francis & Pearson, 1987). This may provide a possible explanation for the low level of emotive reasoning amongst those students purporting to follow a Christian worldview. It must also be remembered that the study focused on adolescents on the edge of adulthood, and consequently, some may be immature in both their general and Christian life experiences. Therefore, as suggested by Hoffman (1975), their capacity for empathy, and hence emotive reasoning, may still be developing.

A number of studies have identified ways to develop empathy in individuals which, although not demonstrated, is likely to be reflected in the students' pattern of informal reasoning as emotive reasoning was categorised as reasoning that included an emotional response to others, such as care, empathy and sympathy. Research has shown that students are more likely to develop empathy when: their own emotional needs are being met (Barnett, 1987), teachers model empathetic behaviour (Pizarro & Salovey, 2002) and provide their students with opportunities to understand, explore, and discuss the perspective of other individuals (LeBlanc et al., 2003).

While it is clear that many students, including those scoring high on the CWS, are using rational modes of reasoning, fewer students with a high level of religious belief utilised this mode of reasoning. One factor that could have contributed to this result is that students are only reflecting the ideas of their faith community, without having an understanding of why they hold that position. While this idea is subjective, and would require further study, it could explain the greater reliance on intuitive reasoning over rational reasoning.

Because rational reasoning remains an integral part of scientific literacy (Bybee, Carlson-Powell, & Trowbridge, 2008; Cavagnetto, 2010; Dawson & Venville, 2009), researchers have examined students' critical thinking and its role in improving the scientific literacy of students (Bailin, 2002; Hand, Lawrence, & Yore, 1999). While the development of critical thinking skills amongst students cannot be assumed to result in an increase in the frequency of rational informal reasoning amongst students, it is possible that students with a more developed repertoire of critical thinking skills would include more rational reasoning when making judgements about SSI.

Strategies which may have a positive effect on students' ability to construct better evidence-based arguments include: students participating in: role-plays (Lin, Chiu, Hsu, & Wang, 2014); the teaching of philosophy to students

(e.g., Philosophy4Children); and a better understanding and recognition of common logical fallacies (Zeidler, Lederman, & Taylor, 1992). The most effective strategy for improving rational reasoning amongst students may be explicit teaching of critical thinking skills through authentic contexts with opportunities for dialogue and debate (Abrami et al., 2015).

The increased use of intuitive reasoning by students measuring high on the CWS is consistent with the findings of Shenhav, Rand, and Greene (2012), who demonstrated that, at least in the adult population, the use of intuitive thinking styles over reflective ones were associated with an increased belief in God. Shenhav et al. (2012) suggest two possible, although not mutually exclusive, explanations for this observation. Firstly, they suggest that an individual who is more inclined to use intuitive reasoning may be more attracted to a belief in God because it supports other intuitive explanations, and secondly, an intuitive belief in God may support the use of intuitive reasoning in other situations. While the students in the study had not been formally taught to identify different modes of informal reasoning within a classroom setting, it is unknown if students had been exposed to different modes of reasoning as a result of their family and cultural background. Questions regarding the role that differences in students' prior exposure to informal reasoning may have in the results observed in this study remain an unexplored area of research into this field of study.

CONCLUSION

When investigating SSI, science teachers need to encourage their students to identify the modes of reasoning that they are utilising and, if necessary, encourage them to actively engage in other modes if they are not already doing so. Given the decreased use of rational reasoning amongst students with high religious beliefs, additional coaching might be required to develop the rational reasoning of these students. Because of the reduced incidence of emotive informal reasoning amongst these same students, it could be beneficial for educators to emphasise to these students the importance of empathy in their purported beliefs. While valuable for all students, the importance of implementing strategies to increase students' rational and emotive reasoning might be of additional significance in faith-based schools. Utilising a deeper understanding of the source of students' concerns about biotechnology, teachers can encourage students to develop a rational argument for their views that can be developed from their Christian or other worldview beliefs instead of relying only on intuitive reasoning.

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