Investigations of Socio-Biological Literacy of Science and Non-Science Students

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Abstract

Australian science education practices, in the way science is both seen and taught, have mostly remained unchanged, particularly with regard to developing scientific literacy in higher education at the first year undergraduate level. A ten item multiple choice survey was employed to examine understanding of socio-biological issues, and comparisons were made between volunteers from three different cohorts;

- a large core biology class which utilises 'traditional' teaching pedagogies,
- a small elective biology class aimed specifically at increasing the socio-scientific literacy of non science students, and
- first year education classes with no science content.

The initial literacy expectations were: most literate - core biology > elective biology > education – least literate. This prediction was based on the level of engagement resulting from the teaching methods employed, in addition to the expected degree of exposure to accurate/quality scientific information students would have received. The pattern that emerged was as predicted indicating that when the subject material is made interesting and relevant, scientific knowledge and understanding of non-science students can be increased to approximately the same level as core biology students, regardless of the students' prior educational background.

Introduction

The number of Australian students who study science, technology, engineering and mathematic (STEM) courses has either remained static or fallen sharply (Krause, Hartley, James, & McInnis, 2005). Australia is rapidly losing ground when it comes to graduate scientific literacy, especially when compared to countries such as Finland, China and Canada (Thomson & De Bortoli, 2006). With regard to its position amongst the 30 countries involved in the Organisation for Economic Cooperation and Development (OECD), Australia is ranked 9th for the proportion of the population age 25-34 with recognisable tertiary qualifications (Commonwealth of Australia, 2008), and 20th out of the countries producing graduates in science and engineering (FASTS, 2010). This is particularly worrying, as annual supply rate of technically and scientifically literate people (currently 3.5%) is well below the needs of the Australian workforce (FASTS, 2010). Yet, "such a decline seems counter intuitive in the context of the technology revolution that has taken place over the same period" (Rice, Thomas, & O'Toole, 2009; p.12).

Scientific literacy not only increases interest in the surrounding world, but also allows for active engagement in discussions of scientific advancements and the ability to be sceptical and questioning of the claims made by others (Rennie, 2005). Since science pervades nearly all aspects of modern society, many educators deem that it should be crucial that all students develop the ability to consider, make decisions on, or resolve current socio-scientific issues through the additional learning of a more science based course (Sadler, 2004). However, many students perceive science to be too difficult, 'boring' and 'irrelevant,' believing it requires copious amounts of background knowledge (Burke da Silva, 2008). These perspectives have, at least partially, produced an avoidance of science-based courses throughout schooling levels (including tertiary and other higher education options). Interestingly and perhaps paradoxically, many Australian universities list 'knowledgeable' as a key graduate quality - referring to an explicit understanding of how knowledge gained in an undergraduate degree can be applied in real world contexts. Yet how can a graduate be considered to have this quality, when they have avoided science? In fact, when undergraduate students without any prior science education try to apply their general/degree-related knowledge to socio-scientific issues, they would be at a disadvantage and unable to make appropriate decisions, because they are less likely to be able to critically examine the scientific validity of a given argument. Rief (2008) explains that this is likely a result of an acceptance of a lack of finer discriminations in non-science domains where terminology with distinct scientific meanings such as "force, energy, momentum and power are often used interchangeably" (Reif, 2008; p.229). Reduced scientific literacy amongst university graduates is problematic, as without at least a basic understanding, this cohort may soon find themselves disadvantaged in today's increasingly technological global environment (Burke da Silva, 2008; Laugksch, 2000).

Education reformers within Australia are attempting to remedy the gaps in scientific literacy by imploring organisations and curriculum developers to teach science the way it is practiced (through investigation); enabling students to better understand the critical concepts regardless of previous education (DeHaan, 2005; McWilliams, Poronnick, & Taylor, 2008). Traditional teaching methods, such as lectures, do have their "uses and rewards" for "individuals committed to [becoming] science specialists" however for "students with non science career goals" other "more flexible" pedagogies should be explored (Duschl, 1988; p.51). Such approaches more readily allow "humanistic and societal issues of science" to be "examined along with the facts of science" (Duschl, 1988; p.51). However one of the main hindrances to changing teaching pedagogies, is the lack of evidence showing that these changes are worthwhile. At the first year undergraduate level, there have been few studies into the area of achieving scientific literacy; and of those that do exist, many deal with either physics or chemistry. To address this, an investigation focused primarily on comparing the biological literacy of science students undertaking a core biology course and two groups of non-science students, one group who were taking an elective biology course and the other group who were not taking any science courses. The investigation also measured whether the teaching method had an effect on biological scientific literacy (BSL), or if simply taking a science course in itself was valuable for improving understanding of current socio-scientific issues.

In 2007, Salamon reviewed how educators and policy makers used the term scientific literacy in higher education. In short, definitions centred around 3 main components – understanding the nature of science (norms and methods); discerning knowledge of terminology and concepts; and astute awareness of the impacts of science and technology on society. This investigation explores, 'scientific literacy' from two of these components – expecting that literate study participants would:

- understand the major concepts within the field of biology.
- be critically aware of the impacts of biological advances on society

An adaptable survey tool, comprising of ten multiple choice questions about current biological societal issues, was developed to determine the scientific literacy (in terms of knowledge and understanding) of first year undergraduates. Analyses were undertaken to determine whether a particular teaching style was helpful in increasing BSL in non-science students. It was expected that students exposed to teaching styles specifically designed for improving BSL, would have higher literacy, since the pedagogies are designed to maintain interest and engagement in the subject. It was also predicted that students in both the core and the elective science courses would display higher BSL than students not involved in a science course (education students). The results were used to evaluate whether current teaching practices at Flinders University increase scientific literacy by providing students with both factual knowledge, and the skills needed to interpret the critical scientific issues that affect them on a daily basis. These findings will provide insight in the development of teaching and learning practices for teaching both science and non-science students; and in doing so, highlight the importance of increasing scientific literacy nationally.

Methodology

Participants were sampled from first year undergraduate students at Flinders University, who were either science or education students (courses are described in Table 1). The primary researcher distributed surveys to volunteers from each population and the number of respondents can be found in Table 2. Surveys were distributed during lectures throughout the period of May-August 2011. Ethics issues, such as identity concerns, were controlled by ensuring that no personal information was asked of respondents, except for student identification number that were collected to prevent double sampling. All surveys were returned to the primary researcher upon completion to prevent confidentiality breaches from arising, and only the primary researcher was involved in the analysis of the results. The number of respondents sampled for each group in this investigation is outlined in Table 2.

Survey design

Previously, literacy studies have used open-ended, true-false, and multiple choice surveys to identify the range of students' misconceptions in relation to particular scientific courses (Brossard & Shanahan, 2006; Laugksch & Spargo, 1996; Tamir, 1991). In many studies, the use of open-ended questions has been shown to provide a better measure of understanding than other methods. However, the downside to this format is the sheer quantity of data collected (Brossard and Shanahan, 2006). In contrast, the true-false format most commonly used in scientific knowledge related studies, may not provide enough information for sufficient analysis when a 'don't know' option is not provided (Laugksch & Spargo, 1996) because respondents have a fifty percent chance of selecting (or guessing) correctly (Brossard & Shanahan, 2006). To prevent either of these issues from arising in this investigation, a multiple choice survey was used in this study.

Table 1: Pedagogies employed and teaching goals of first year undergraduate science and education courses taught at Flinders University.

Course	***Description***
Core Biology – Molecular Basis of Life (BIOL1102)	The largest first year and core biology course at Flinders University, with approximately 600 students enrolled each year. Emphasis is placed on students gaining a basic understanding of subjects, including: biochemistry, the nature of genetic material (such as its replication and expression), the function of intracellular organelles and the evolution of organisms from single cells to multicellular beings (Flinders University, 2011a). The course employs fairly traditional methodologies (a series of integrated lecture, tutorial and laboratory sessions), and is typically taught as a large lecture based course with multiple instructors who teach on their areas of expertise.
Elective Biology – Biology and Society (BIOL1112)	Redesigned in 2006, the subject specifically aims to improve scientific literacy of 60 enrolled students by providing students with an opportunity to develop their critical thinking and problem solving skills (Flinders University, 2011b) by exploring issues currently being debated within the community through a mixture of both theme based lectures and in-class discussions with experts in respective disciplines (Burke da Silva, 2008). The course is similar to one of the most significant and sustained international elementary school curricular movements (‘Science, Technology and Society’ (STS)).
First year education courses EDUC1120, EDUC1222, and EDUC1223	Three first year education courses (EDUC1120, EDUC1222, and EDUC1223) were sampled in order to provide a large enough sample size for thorough investigation, approximately 300 students take these courses. These courses were the largest non-science first year courses at Flinders University and acknowledged the historical and political aspects of both education and teaching (Flinders University, 2011c). These courses encompass the range of education settings from early childhood through to tertiary education, and employ the traditional lecture-tutorial method.

Table 2: Number of survey responses (including overall total) collected during May – August 2011.

Survey Group	***Number of Respondents***
Core Biology	194
Elective Biology	24
First Year Education Students	96
Total	*314*

The questions in this study were developed from a range of end of chapter questions from first year biology textbooks. The use of these sources helped to maintain a reasonable level of cognitive ability in the survey, and helped “diagnose” misunderstandings because these questions require students to identify the “best” answer (Tamir, 1991, p.188) in addition to revealing the level of biological knowledge. In a teaching and learning context, this information provides essential feedback to science educators, indicating whether it is necessary to revisit content because “most of the students in the class are not sure about a particular item” (Tamir, 1991; p.189). Further by testing understanding of key socio-biological issues, not just right vs wrong knowledge, it was possible to make inferences about student’s literacy. These key multiple choice questions were combined with a selection of attribute questions that enabled additional levels of analyses. The survey was kept to a two page maximum, with ten main courses covered in order to reduce the burden on respondents and prevent non-responses (see Appendix A).

Data analysis

Participant responses were scored out of 10. This score could be calculated because each MCQ had a correct answer that was provided by the authors of these publications. Correct responses were coded as 1, and an incorrect or blank response was coded as zero, and the sum of the participant’s ten responses was used to determine the respondents’ level of biological literacy. By using this interval variable, the amount of difference between categories could be specified effectively through using a combination of unpaired t-tests.

Results

Figure 1 shows that biological literacy scores were highest in the core biology class and lowest in the non-science students who were not taking any science courses (education class). No statistically significant difference was found between the core biology and elective biology students in terms of the number of correct answers. We therefore combined the two biology groups and compared them to the education students and found a highly statistically significant difference ($P<0.0001$, $t=6.857$) . Table 3 further reveals these differences, with the percentage of correct responses from the non-science group often being below the mean, and the percentage of correct responses in the science groups being above it. One important consideration is that the core and elective students higher scores could be attributed to courses being covered as part of the subject matter of the course prior to surveying. This is particularly evident in the elevated literacy levels in the BIOL1112 (elective) cohort regarding the subjects cloning, evolution and GM food, where they even outscored the core biology students. However, this is not thought to be problematic, since there was no explicit teaching directed toward the survey. Instead, it implies that even a small amount of education about a subject (1 week of lectures) can significantly increase scientific knowledge. Further explorations of the influence of course content on biological literacy were revealed when a two-tailed unpaired t-test was applied to the data set. Significant differences were found specifically between the knowledge of elective biology students and the education students ($P=0.020$, $t=2.345$). This is an important finding in regard to teaching pedagogies and course content, because the elective biology students are not enrolled in a science degree program, therefore the difference in BSL between these students and the education students likely reflects literacy gains from involvement in the BIOL1112 course.

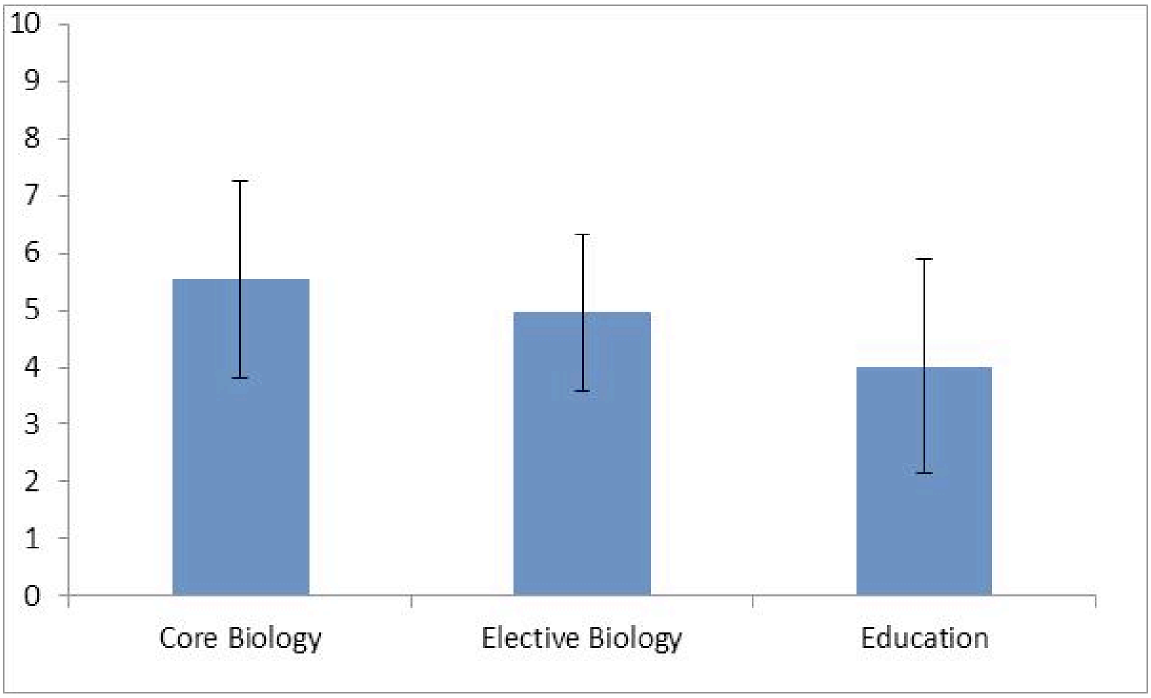

Figure 1: Comparison of average biological scientific literacy scores with standard deviation for each survey respondent group.

Table 3: Actual (and overall mean) percentage of correct answers selected by each respondent group, and mean literacy scores for each group.

Question	*Course*	*(Core) BIOL1102*	*(Elective) BIOL1112*	*Education*	*Mean*
1	Human Cloning*	47%	54%	40%	47%
2	Climate Change	43%	38%	36%	39%
3	Extraterrestrial Life	47%	42%	45%	45%
4	Evolution*	88%	92%	73%	84%
5	Science and Technology	78%	58%	61%	66%
6	Bioremediation	45%	29%	9%	28%
7	Human Genome Project	70%	67%	46%	61%
8	Common Cold	26%	21%	27%	25%
9	Nature Reserves	37%	13%	31%	27%
10	GM Food*	77%	88%	36%	67%
	Mean literacy score	56%	50%	40%	

*Subjects covered in BIOL1112 but not BIOL1102

Despite the fact that the average core and elective biology student knew more than an education student (shown in Figure 1 and Table 3), there were still a number of misunderstandings held by all respondent groups. These shared misunderstandings are shown in Table 4, and included important issues such as climate change, human cloning and the common cold. In addition to identifying commonly shared misunderstandings, the data was also examined for significant differences between the numbers of respondents that answered correctly compared to those who selected the most common incorrect answer. Question 5 (science and technology), showed better understanding amongst the core biology than the other groups. Education students scored poorly on question 6 with 38% of participants believing that bioremediation is used to introduce correct genes into individuals that have genetic diseases, and only 9% knowing that it is in fact used to decrease pollutants in the environment. This knowledge gap did not exist with the core biology class who had a substantial level of BSL regarding bioremediation with 45% of students scoring the correct answer. With regards to the genetically modified food (question 10), students from both biology courses (core = 77%, elective = 88%) possessed a greater level of understanding on the issue compared to education students (36%), who had no prior science-based education on this course, performed poorly on this question. The knowledge the core biology students had about genetic modification can be attributed to their general understanding and perhaps interest in the subject area, whereas the elective biology students likely gained this understanding from the BIOL1112 course as it was part of the curriculum.

Table 4: Common socio-science literacy survey errors across all respondent groups.

Course	*Commonly Selected Incorrect Answers*
Human Cloning	The only mammal to be clone successfully so far is a sheep named Dolly
Climate Change	There is a mixed consensus among scientists whether or not climate change is due to human activity
Extraterrestrial Life	We have discovered fossils of microbes on Mars
Evolution	The Earth was formed about a million years ago, primitive life emerged about 100,000 years ago, and humans emerged only a few thousand years ago
Human Genome Project	To identify the legal and ethical implications resulting from gene identification
The Common Cold	The antibiotic would do nothing to the virus itself, but could prevent possible effects such as pneumonia or ear infection

Discussion

Biological literacy gains from course content

This investigation has looked at the differences in biological literacy of science and non-science students in their first year of university, and whether the teaching method had an effect on BSL. Not surprisingly, the pattern that emerged is [highest BSL] core biology student (pure science) > elective science student > education student (no science) [lowest BSL]. However, this pattern also does not necessarily denote the effectiveness of teaching practises. What was most interesting, in terms of teaching practises, was the amount of knowledge gained by the elective biology students whose background was similar to the education cohort not taking a science course. Especially when you consider that the socio-science literacy levels of the elective students, was on par with the core biology students (who likely had more biological literacy to begin with, see Buckberry and Burke da Silva in press). The similarity in scores of core and elective biology students provides strong support for the notion that when science is taught innovatively (so that subject material is made both interesting and relevant to students), biological literacy can be increased (to approximately the same level as that of core biology students) regardless of the students' prior educational background, and in a relatively short period of time. However, some caution should be taken with this assumption, because by electing to take a science course, the BIOL1112 students have potentially demonstrated an interest in science (although many said they took the course because it did not have a final exam). This may mean that these elective students had a higher interest in scientific courses (more than the education students), meaning that the change in knowledge may be slightly biased in this direction. It is also possible that the BSL gains are related to their interest in science (motivation) rather than pure engagement through the course. However, since the proportions of correct responses to socio-scientific issues covered in the participants course was higher than for issues not covered by the course, this analysis does provide insights into the effectiveness of the teaching practises employed in BIOL1102 and BIOL1112 (see Table 1).

Learning science at any level is considered to be a practical process, with thorough understanding of the main principles and concepts usually requiring active participation. ‘Traditional’ lectures are a suitable medium for (briefly) presenting provocative ideas, alternative perspective, and conflicting theories (Murphy, 1998), in addition to helping students make stronger connections between theory and practice (in separate disciplines). This style of teaching is also cost effective and convenient (Wyckoff, 2001). However, one of the major criticisms of lectures is that they often have too much ‘rote-learning’ content thereby neglecting deeper learning strategies (Murphy, 1998). Students often remark that this method provides “little opportunity for conceptual development [by testing] little more than their ability to remember” (DeHaan, 2005; p.254). Further, in these passive learning settings, if students “fail to understand what [is being conveyed] during the first ten minutes” they “may be unable to understand the rest of the lecture” resulting in “meaningless” note-taking (Reif, 2008; p.408). The use of this pedagogy also leads to poor retention of students (Seymour & Hewitt, 1997), with as many as 50% withdrawing within two years of attending larger lecture based science courses, (DeHaan, 2005; Wieman, 2007). These issues highlight two main areas of need. First - making science more appealing and intellectually rewarding to study; next - maintaining student engagement through the use of innovative teaching pedagogies (Burke da Silva, 2008; DeHaan, 2005).

The teaching in BIOL1102 and particularly BIOL1112, incorporates innovative methods, presenting case studies and current socio-scientific issues to students to encourage conceptual development and critical thinking. A review of the elective BIOL1112 course in 2008 revealed that 85% of students attended the lectures (compared to 60% attendance at the core biology course), and after completing the elective “58% of students who were not enrolled in the core biology course went on to enrol in the second semester core course” (Burke da Silva, 2008). Student comments from BIOL1112 revealed that the course was “very confronting and mentally challenging,” but also “enjoyable,” one student even commented that “all students should take up this course!’’(2008; p.4). The attendance levels and student comments presented in Burke da Silva’s 2008 paper, in addition to the knowledge gains found in this investigation, demonstrate that socio-science literacy gaps can in fact be remedied through biology courses with innovative teaching methods. In addition, these innovative methods can motivate students to undertake further study – keeping both science and non-science students involved and engaged in science beyond first year.

Potential influences by participant background

The increase in the levels of diversity and student numbers in Australia has created a gap between universities’ expectations of their students, and students’ expectations of their university (especially in regard to previous scientific knowledge requirements) (Flinders University, 2011d). The wideness of this gap is now considered to be highly important as students’ experiences of science within their first year of university can significantly affect future academic success in similar courses and perseverance throughout the rest of their undergraduate degree (Flinders University, 2011d). Whilst it is not always productive to reflect on failings of previous science experiences to impart scientific knowledge in these types of studies, it is necessary to remember that every student has some form of scientific past that will underpin their learning. For example, with mature age students, their time away from study may have put them (and their cohort) at a literacy disadvantage - since science is a field that is “changing at an ever increasing pace” (Burke Da Silva, Hunter, & Auburn, 2008; p.2). Through examining the proportion of participants who studied science at school, and also who entered university from school, it was possible to consider the scientific history that participants brought with them. The majority of respondents within the core biology group (88%) not only studied science at high school, but also entered university directly after the completion of their year 12 studies (79%). So it is possible that these factors positively influenced their biological literacy scores. Within the other respondent groups, only 63% elective biology and 70% first year education students studied high school level science; and 38% education students and 88% elective students reported direct entry to university from high school. Students with no break between school and university, who had studied science at high school may have possessed a better understanding of science terminology and current socio-science issues resulting in a higher base line of biological literacy in these participants (many of which formed the core biology cohort). However, the link between scientific literacy and high school science is not clear cut, and it has been reported that “students who have had [an] extensive [high school education in science can] have similar deficits” to students who avoided science (Alters & Nelson, 2002; p.1893). It may be possible to quantify this, by comparing this study’s results to future first year cohorts, as the new South Australian high school certificate requirements do not require school leavers to undertake as many (if any) science courses (SACE Board of SA, 2012). It will be interesting to see if the Alters and Nelson findings hold, and also whether the difference between the BSL of core science students and non-science students revealed in this study increases even more.

It is also worth mentioning that many science-based degrees at Flinders University require some prerequisite knowledge of STEM courses and occasionally higher tertiary entrance (TER) scores to gain entry. So it is possible that both prerequisite knowledge and higher TER scores contributed to core biology’s higher BSL score - especially as BIOL1102 is a compulsory first year subject for many such degrees. This could be why the average core biology survey results were significantly better than any other respondent group (Figure 1). Closer analysis of the respondent demographics revealed that the students undertaking the core biology course did have higher TER (mean: 80.53) than those enrolled in the education courses (mean: 73.96). Whilst not a reflection on effective teaching practises, this was an interesting finding since “one of the perceived concerns [often] expressed in relation to the uptake of science related studies at university has been a perceived decline in the academic background of entrants...as measured by the mean ENTER scores” (Ainley, Kos, & Nicholas, 2008; p.42).

Increasing socio-scientific literacy in university graduates

Over the last decade, many educators have come to believe that it should become crucial that all students develop the ability to consider, make decisions on, or resolve current socio-scientific issues through the additional learning of a more science based course (Sadler, 2004). Dobson (2007) expressed a positive shift in enrolment in science, with more students taking science as part of a combined degree, however, he also points out that the majority of students in these dual degrees pick electives from the disciplines other than science, which is creating “illusory” growth about the “expansion of science enrolments” (Dobson, 2007, p.1). This then suggests that although students are beginning to recognise the importance of science, they are still not willing to select an additional science based course from those outside of the requirements for their degree. In addition to students limiting science study requirement to core-plan courses, our study results (particularly the lower level of performance observed on those courses students had not been exposed to beforehand) shows that students also limit their views in science to the course content. This suggests that even within university settings, students may be limiting themselves to only learning subject material that is covered in class, rather than exploring how the content fits into the greater body of science. This highlights the importance for educators to be highly selective with course content as there is a finite limit to the amount of subject material that can be covered sufficiently within a thirteen-week teaching semester. Furthermore, since student are limiting both their exposure to 'pure science' and the content within, the idea of producing graduates who are life-long learners with the ability to critically consider socio-science issues seems like a dream. We propose that elective courses such as BIOL1112 Biology and Society need to become part of the core undergraduate curriculum - because the reality is that "people from every walk of life can become important forces in shaping the way science, science facts and technological products are constituted in various arenas of public life" (McGinn & Roth, 1999). As seen throughout this study, students who are exposed to relevant scientific information over an extended period of time are able to develop considerably more knowledge on socio-scientific issues that can assist them when making impacting decisions (their prior knowledge often making it easier to predict likely outcomes and consequences) (Reif, 2008). The provision of at least a basic background knowledge of the roles that science plays in modern day society and how it affects every day problem solving and decision making is therefore a must. If current traditional pedagogies continue to be employed, students will continue to lack the preceding advantages and many will still fail to consider potentially useful options or not make any decisions at all (Reif, 2008).

Conclusion

The results of this investigation have shown that biological scientific literacy is highest in students enrolled in an undergraduate science degree, and lowest in those who have not undertaken a science elective. It has also shown that there are significant literacy gains in non-science students when they are informed about socio-scientific issues through a non-traditional science course. This investigation has begun to show the scientific value in providing a first year science elective that is relevant to non-science undergraduates. However further analyses need to be undertaken to resolve the most effective teaching strategies for increasing scientific literacy in university graduates so that they become more science-conscious citizens.

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Appendix A: Student Survey

Student Number:
Male/Female:
What degree are you currently enrolled in?
Did you enter university directly from high school? Y/N
If no, please describe (i.e. worked in... or took a gap year to...)

Did you study any science topics at high school? Y/N
If yes, which subjects?

1. Human Cloning
   a. Humans have already been cloned
   b. While we are not able to clone humans yet, other animals such as sheep, goats, rabbits, pigs, cats and deer have been successfully cloned
   c. The only mammal to be cloned successfully so far is a sheep named Dolly
   d. Cloning has only successfully worked on organisms such as insects

2. Climate Change
   a. The overwhelming majority of climate scientists agree that human activity is changing our climate
   b. There is a mixed consensus among scientists whether or not climate change is due to human activity
   c. There is a mixed consensus among scientists whether climate change is actually occurring
   d. Most scientists believe that human activity is not affecting our climate

3. Extraterrestrial life
   a. We have discovered life on planets outside our solar system
   b. We have discovered life on Mars
   c. We have discovered fossils of microbes on meteorites from Mars
   d. We have yet to discover any extraterrestrial life

4. Evolution
   a. The Earth was created less than 10,000 years ago and all organisms, including humans, appeared independently of each other
   b. The Earth was formed about a million years ago, primitive life emerged about 100,000 years ago and humans emerged only a few thousand years ago
   c. The Earth was formed about 4.5 billion years ago, primitive life emerged about 3 million years ago, and modern humans emerged about 200,000 years ago

5. Science and Technology
   a. The words “science” and “technology” are interchangeable
   b. Technology encompasses all machines and activities created by humans; science is the study of technology
   c. Science is the study of nature; technology is the application of science
   d. Science is a logical methodology by which to study a subject; technology is the study of nature

6. During bioremediation, micro-organisms (such as bacteria) are used to
   a. Clone genes from multicellular organisms
   b. Introduce correct genes into individuals that have genetic diseases
   c. Decrease pollutants in the environment
   d. Produce useful products such as insulin for diabetics

7. Which of the following is **not** a goal of the human genome project?
   a. To identify all human genes
   b. To sequence the human genome
   c. To identify the legal and ethical implications resulting from gene identification
   d. To develop an accessible program that holds the information collected from the project
   e. To clone a human

8. The Common Cold is caused by viruses which enter the body through the nose and throat. If you treated a cold with an antibiotic, what would happen?
   a. The cold would get better more quickly than if you just took ordinary paracetamol
   b. The antibiotic would do nothing to the virus itself, but could prevent possible effects such as pneumonia or an ear infection
   c. It would not hurt the body, even if it had no effect on the virus
   d. It would be dangerous to the body as antibiotics do nothing to viruses but increase the possibility of harmful bacteria becoming resistant to the antibiotic

9. All of the following statements regarding nature reserves are true, except:
   a. Constructing several smaller reserves may be better than a single large reserve with the same total area
   b. A single large reserve is always better than several smaller reserves with the same total area
   c. Disease can be a problem in reserves that contain ‘corridors’ between them
   d. Edges frequently have their own biological communities

10. Why might the genetically modified crop ‘Golden Rice’ be valuable to humans in developing nations?
   a. More rice would be produced per acre of land
   b. The rice would be completely resistant to pests and diseases
   c. The rice would produce higher levels of essential vitamins and minerals, such as vitamin A