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BIOTECHNOLOGY EDUCATION: TOPICS OF INTEREST TO STUDENTS AND TEACHERS

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This paper presents the findings of a survey that investigates the biotechnology topics of interest according to students and teachers for inclusion in biology lessons and reports on the similarities and differences in teachers' and students' biotechnology topics of interest. The study is of significance as biotechnology has been identified as a key area of technological and economic importance worldwide yet there is scant literature relating to teachers' and students' interests concerning biotechnology education topics. 500 students and their 15 teachers completed the survey. Interviews were conducted with 3 teachers and 60 students. Responses indicate there is a mismatch in the interests of students and teachers, and what they perceive as being possible topics for inclusion in biology and biotechnology lessons. Where teachers are provided with the freedom to design and assess their own units of work, this mismatch of interests causes problems. The study found students withdrawing from biology courses in post compulsory settings due to lack of interest, and perceived lack of relevance of the course. It is possible that this lack of agreement on topics of interest is a factor in the world wide decline of enrolments in the sciences.

Introduction

Aims of biotechnology education

"A recurring evidence-based criticism of traditional school science has been its lack of relevance for the everyday world" (Aikenhead, 2006, p. 31). Many students do not see the relevance of the school science curriculum, a factor which contributes to the low number of students pursuing science courses in high school and university (Baram-Tsabari, Sethi, Bry, & Yarden, 2006). There is a need for the science curriculum to be relevant, modern and reflective of the needs and values of the community. It is argued that in upholding these curricular guidelines, there is an important place in a modern science curriculum for biotechnology education to contribute to these morals and values. Biotechnology is increasingly playing a role in the daily lives of citizens and so of foremost importance is public understanding of this new technology. This understanding cannot occur without a sound and comprehensive biotechnology education. If people are not educated in this field of science and technology, they cannot have a meaningful participation in the public debates concerning these issues. A biotechnology education is required if students, and thus future citizens, are to be sufficiently informed to be able to effectively engage in public debate. In a contemporary science education, foundation knowledge of biotechnology principles and the related ethical issues are essential for effective engagement in public debate concerning biotechnology. The teaching of biotechnology therefore must provide for a sound understanding of its scientific basis. In addition, there needs to be opportunities for students to develop critical thinking and decision-making skills regarding the ethical use of biotechnology.

The Australian government and private sector interests strongly support the concept of biotechnology education as biotechnology is regarded as a very important development for both scientific and economic progress. The national science framework also recognizes the need for science students to be made aware of biotechnology in the Australian science curriculum. Curriculum planners and educators are therefore encouraged to incorporate biotechnology into science curriculum; however the level of biotechnology education occurring in Australian schools is minimal and lags well behind the levels taught in both the United Kingdom and the United States of America.

The teaching of biotechnology within a science education presents teachers with many challenges. The vast volume of information rapidly emerging in biotechnology leads to a number of practical problems in teaching it to science students. Concern initially relates to teacher discipline knowledge, and how teachers will access the new scientific knowledge. Following on from this, and assuming such a discipline knowledge base in the teachers, the teachers are faced with questions about what knowledge is attainable by the students, and what ethical issues relating to biotechnology could be taught. Teachers need to address how these topics can be taught effectively. Biotechnology also presents broader philosophical questions to the teacher and their students, for example, questions concerning the origin of life, and how life itself is defined.

Biotechnology topics that could be taught in a general biology curriculum include: bioethics in biotechnology, biotechnology in agriculture, medicine, environmental science and industry, defining biotechnology, molecular biology of cancer, organismal biochemistry, microbiology, genetic engineering, human genetics and genomic library, molecular biology as a discipline, and DNA fingerprinting. However, teaching all of these topics is not practical. A mandate already exists in the case of the Queensland biological science curriculum to allow teachers in that state to use their professional judgement in making decisions on what materials are taught in view of their specific student circumstances (Queensland Studies Authority, 2004). To date, no formal planning has occurred in relation to determining the particular attitudes and interests of the key stakeholders – that is the students and teachers. This study aims to determine biotechnology interests of Queensland secondary school students and their teachers.

Biotechnology in the curriculum

Chen and Raffan (1999) investigated the knowledge and attitudes of Taiwanese and United Kingdom students aged 17-18 regarding biotechnology. The results from the study indicated a limited understanding of biotechnology and some differences in student understandings between the countries. For example, students in Taiwan did not demonstrate the diversity of definitions and examples that the UK students did. Chen and Raffan suggest this may be accounted for by the different curriculum approaches both countries have. The UK curriculum allowed for a number of learning opportunities where students had access to biotechnology resources as textbooks, media, and contact from scientists and general studies materials; as well as opportunities to discuss the ethical issues associated with biotechnology. This was in contrast to the Taiwanese curriculum, which was more demanding in the sense that students studied more subjects and were more examination orientated in their learning context.

Chen and Raffan (1999) concluded that a good biotechnology education has implications for students and teachers. It is not just intended to promote biotechnology or produce students with positive attitudes to it. It gives the students current and accurate knowledge, and the opportunities to form their own views, based on their understandings of risks, benefits and disadvantages of modern biotechnology. For teachers, thorough preparation of subject material and opportunities develops informed views on controversial biotechnological topics are important pedagogical goals. Overall, Chen and Raffan (1999) suggested that the end product of biotechnology education is to assist students to develop independent thinking skills and be better prepared to think about and deal with controversial topics encountered in their future lives.

Dawson and Taylor (2000) support biotechnology education, stating that "If our students are to become well-informed decision makers then they need to be aware of the practical applications of current developments in biotechnology, and appreciate the social and bioethical implications of this relatively new and controversial science" (p. 184). It has been suggested (Schibeci, 2000) that as biotechnology is a rapidly developing technology with much health, economic and environmental benefits to Australia, the teaching of biotechnology and its impact on the community is of importance. Schibeci advocates that rather than devote a special unit on ethics or the social implications of science and technology, these topics can be taught with the use of a variety of techniques such as laboratory exercises and case studies. Regardless of the methods employed in their teaching, Schibeci further recognises that the teaching of biotechnology is important both in terms of its science as well as providing a vehicle to examine ethical issues associated with its use.

Crucial to the development of biotechnology education in secondary classrooms are the teachers themselves. Whilst Australia has syllabus mandates and commonwealth funded web sites e.g. *Biotechnology Online* (http://www.biotechnologyonline.gov.au/) to develop biotechnology skills and understandings in the classroom, there seems to be reluctance from the teachers to present biotechnology lessons. Steele and Aubusson (2004) interviewed a number of teachers to determine why they were not presenting biotechnology in their biology classrooms. Although the teachers appeared to have a sound understanding of the content, they considered biotechnology was too difficult for the students, and this would disadvantage the students in the university entrance examinations. Another problem according to the teachers was the lack of opportunity for practical work in the classroom.

Biotechnology attitudes and interests

Researchers have shown that becoming a scientificaly literate person is not a high priority for many students (Atwater, Wiggins, & Gardner, 1995; Zacharia, 2003). A particular need identified by Zacharia, is to investigate the extent the learning experience enhances the students' attitude towards science learning. Zacharia found that a teacher's attitude toward the subject matter and its effective presentation was as significant as the students' perspectives in determining the success of the teaching/learning experience. Fishbein and Ajzen (1975) laid the foundations for the study of attitudes. They argued that 'attitudes' are a function of the individual's beliefs and an evaluative response associated with the belief. Therefore beliefs affect attitudes, and attitudes then affect intentions. This connection between attitude and intention is important when considering the impact a teacher has on the curriculum and learning environment.

Student and teacher attitudes have been investigated in various, but separate studies over recent decades. Haladyna and Shaughnessy (1982) posited students' attitudes are determined by an interaction of the teacher, the student and the learning environment. Simpson and Oliver (1990) later found the preparation of the teacher, the nature of the hands-on activities, and the student involvement in the learning are important variables related to student attitude. Hewson, Kerby, and Cook (1995) argued that teachers' conceptions and attitudes have a strong influence on science teaching and learning. Recent research (e.g. Pintrich & Schunk, 2002) indicates a wide range of factors impacting on learning of which student interest plays a significant role. Students are rarely taught topics of interest, and they generally loose interest during learning (Prenzel, 1998).

Dawson and Schibeci (2003), and Gunter, Kinderlerer, and Beyleveld (1998) both conducted surveys of secondary school students attitudes about what are acceptable biotechnology processes. Students supported the use of micro-organisms for specific purposes such as beer manufacture. Students did not support the genetic modification of plants for food, and even less support was reported for the genetic modification of animals and humans. Dawson and Schibeci also investigated biotechnology understanding in 15-16 year old students. They found that after 10 years of compulsory schooling in science, the majority of students did not understand the processes of biotechnology. The few studies that have investigated the relationships between biotechnology understandings and attitudes have been inconclusive in their findings (see Olsher & Dreyful, 1999; Dawson & Schibeci, 2003).

There is some support for the notion that scientific interest affects science achievement (Benbow & Minor, 1986; Kahle & Meese, 1994; Simpson, Koballa, Oliver, & Crawley, 1994). Whilst these studies relate to science education none relate directly to the biotechnology subfield. The emphases of these studies relate to gender and gifted and talented students, but the findings are not consistent. One reason postulated by Chambers and Andre (1997) for inconsistent results in interest research is that the interest instruments used may not be valid instruments. By considering Ajzen and Fishbein's (1980) theory of reasoned action, it is possible that inconsistent results may arise from the use of a domain-general instrument rather than a topic-specific instrument. It can be argued that domain-general attitude and interest measures should not be expected to produce quality results in topic-specific studies. Topic-specific attitude and interest instruments are necessary to explore attitude and interest relationships. Consistent with this notion, the present study examines biotechnology interests through a purposely constructed topic-specific instrument.

Importance of the study

Research in this domain is needed for a number of reasons. There is a scarcity of research into biotechnology education. A second reason is that teachers' attitudes have an effect on science classroom practice in general, but the extent is not known in relation to biotechnology. A third reason is to investigate the links between biotechnology interests of both students and teachers – a yet untapped area. As far as the author is aware, there is no published research which compares the biotechnology interests of students with those of their teachers.

This paper can be regarded as a contribution both to the as yet scarce literature of biotechnology education, and to the recent growth area of "student voice" (Jenkins & Pell, 2006). Jenkins and Pell make the assumption (although untested) that an increase in knowledge about students' interests, the more feasible it will be to develop curricula that is engaging and that empowers otherwise silent voices in debates surrounding biotechnological issues. The underlying issue is the curriculum relevance seen from the point of view of the students, rather than that of the teacher or curriculum developer.

The aim of this study is to provide data on student and teacher interests relating to biotechnological topics and processes. The present paper is a component of a larger study that explores student and teacher biotechnology knowledge, as well as teacher skills and professional development needs across the areas of environmental biotechnology, agricultural biotechnology, genetically modified foods, human uses of biotechnology in science lessons.

Survey methodology and statistical analysis

A series of surveys (Biotechnology Education Learning/Biotechnology Education Teaching Survey - BELBETS) were used with 508 15-16 year old students of senior biological science and their 15 teachers from eight secondary schools scattered throughout Queensland, Australia. All Year 11 biology students and their teachers present on the days the surveys were administered completed the survey. The students had unlimited time to complete the survey, and all students could request assistance with reading or defining terms. Every attempt was made to ensure that no student was disadvantaged due to poor literacy skills or unfamiliarity with the statement topic. However, eight student surveys were discarded. Of these, six students did not complete the survey in any meaningful fashion (they answered 'Strongly Agree' or 'Strongly Disagree' to all statements or made no attempt to respond to any statement at all); whilst the remaining two students left major sections blank. A small pilot study involving 12 Year 11 students was conducted to seek information on the wording and readability of the items. These 12 students and their school were not selected as part of the larger study.

This paper reports the initial findings of the 500 students and their 15 teachers. It is acknowledged that the teacher sample is small, and therefore statistically unstable. The survey (Appendix) used a five point Likert scale (Strongly Agree, Agree, Neutral, Disagree and Strongly Disagree) with items adapted from Dawson and Schibeci (2003) and Chen and Raffan (1999) and Biotechnology Online (2001). Additional items were created based upon general readings and Internet coverage. The student and teacher surveys vary slightly. The statements differ in that a student version is written in the following way: *I would be interested in learning about cloning.* Whereas, a teacher would read the same statement as: *I would be interested in teaching about cloning.*

The results of the survey were coded, and analysed using the Statistical Package for the Social Sciences (SPSS). Interviews were held with 60 students and three teachers (from three geographically different schools) who had responded to the survey. The interviews were to establish reasons for which the students and teachers gave their particular responses. All 60 students, and 1 teacher were interviewed by the researcher or a research assistant. The remaining two teachers were interviewed via telephone. The survey contains six factors: the first factor relates to biotechnology in general. Three factors relate to indirect human uses of biotechnology: environmental, food, and agricultural. One factor relates directly to human use of biotechnology. The remaining factor relates to the classroom use of biotechnology: Science Lesson Topics.

Table 1 reports the statistical data relevant to the internal consistency reliability (Cronbach alpha coefficient) and discriminant validity (factor loadings and interscale correlations). The alpha reliability of the scales ranged from .69 to .91 indicating strong internal consistency within each scale. Interscale correlations were generally low, indicating that each scale measured an individual property. Factor loadings for individual items were generally above .5, indicating acceptable association between items and scales. Acceptable divergent validity is shown as the Cronbach alpha's are greater than the interscale correlations. Table 2 reports the Pearson Chi-square statistical data. These results indicate that corresponding responses between the students (BEL) and the teachers (BETS) were different enough in four of the six factors enabling generalisations to be made.

Table 1. Factors, number of items in each factor, Cronbach Alpha, Factor Loadings, and Interscale Correlations for the 'attitude' items

Factors	Participant	No of items	Cronbach Alpha	Factor Loadings	Interscale correlations
General	Student	6	.75	.76-.85	.22-.67
	Teacher		.91	.69-.92	.29-.35
Environmental	Student	8	.78	.72-.85	.33-.85
	Teacher		.85	.49-.68	.29-.45
Food	Student	7	.69	.59-.87	.35-.49
	Teacher		.88	.75-.95	.33-.51
Agricultural	Student	8	.82	.49-.74	.30-.54
	Teacher		.76	.61-.79	.32-.55
Human uses	Student	2	.78	.56-.90	.28-.67
	Teacher		.82	.58-.79	.29-.78
Science lesson topics	Student	4	.88	.61-.79	.21-.51
	Teacher		.90	.71-.82	.26-.57

Table 2. Pearson Chi-square for the 'attitude' items

Factors	BELBETS Item Numbers	Pearson Chi-square
General	26 (27), 27 (28), 28 (30), 29 (32), 30 (34), 31 (36)	19.0265*
Environmental	32 (37), 33 (38), 34 (39), 35 (40), 36 (41), 37 (43), 38 (45), 39 (47)	3.9079
Food	40 (49), 41 (51), 45 (58), 46 (60), 47 (62), 48 (63), 54 (72)	2.6768
Agricultural	42 (52), 43 (54), 44 (56), 49 (64), 50 (65), 51 (67), 52 (69), 53 (70)	15.1913*
Human uses	55 (74), 56 (76)	19.9474*
Science lessons	57 (77), 58 (78), 59 (79), 60 (80)	95.0631*

Note: Item numbers in parentheses are teacher survey item numbers, without parentheses are student survey item numbers. The asterisks indicate if the Chi-square statistic was statistically significant between the student and teacher (* $p < .005$).

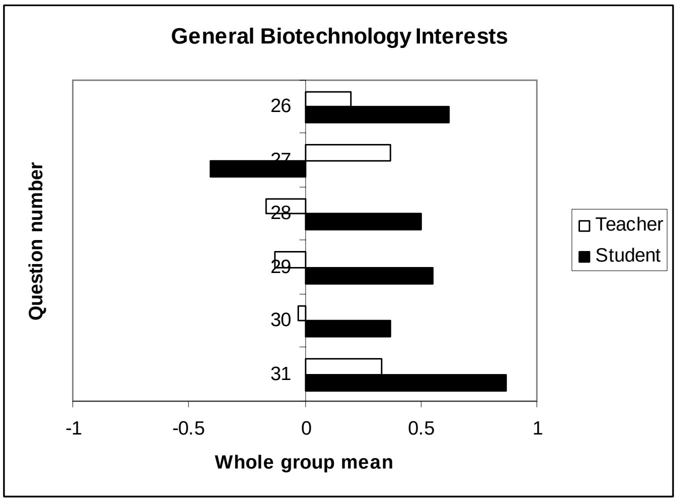
Results and discussion

To facilitate comparisons between the student and teacher responses a mean score was calculated for each item statement. Student and teacher data is treated separately to allow comparison between the student and teacher. Using responses of the whole group (either student or teacher) and by scoring 'Strongly Agree' responses as 1.0, 'Agree' as 0.5, 'Neutral' as 0, 'Disagree' as -0.5 and 'Strongly Disagree' as -1.0 the mean is calculated for each item. As the mean approaches a value of 1, it indicates affirmation of the statement, and as the whole group mean approaches -1, it indicates rejection of the statement (Skamp, Boyes & Stanisstreet, 2004). By plotting the 'Whole Group Mean' in a horizontal bar graph, a visual impression of the relationships between student and teacher responses is possible (for example, see Fig. 1). The analysis of the data is presented around the four factors that revealed a statistical significance between the students and the teachers. The first significant factor relates to interest in general biotechnology. This is followed by agricultural uses and human uses of biotechnology. Finally the science lesson topics of interest are presented.

General biotechnology interests

The general biotechnology factor presented students and teachers with statements relating to natural antibiotics, ethics, DNA and cloning. It was considered important to discover educational interests relating to these issues as technological and scientific advances currently outpace the capacity for society to keep abreast with their current applications.

To facilitate comparison between student and teacher responses, it is convenient to compare the whole group mean for the student with that of the teacher. Figure 1 clearly shows this difference graphically. For example, student item 26 (teacher item 27) shows the student whole group mean of 0.62 which indicates a good agreement with the statement. Compare this to the teacher whole group mean of 0.20. The students indicate they are quite interested in testing natural antibiotics, yet teachers are not so interested. This difference in interests is more apparent with the remaining statement items. From Figure 1, it is obvious students and teachers have very different interests in terms of DNA, and genetic codes and sequencing. Item 31(36) indicates that both teachers and students are interested in producing a plant clone; however students are clearly more interested in this activity than teachers are.



Note: As the mean approaches a value of 1 it indicates affirmation of the statement, and as the mean approaches -1 it indicates rejection of the statement.

Figure 1. Whole group mean scores for interests relating to general biotechnology issues

Clarification of responses was sought from students and their teachers. Michelle, a student at School 6 was quite emphatic about not being interested in investigating media articles relating to ethics (Statement 27 (28)):

Michelle: No, I am not interested in that idea 'cause it is boring. Um, the boring bit is reading the paper articles or long print-outs from the web. I am not into reading things like that. The ethic thing might be interesting, but I probably won't give it a go to find that out.

One of Michelle's classmates was very keen to see DNA and the notion of DNA actually being able to be extracted outside a forensic laboratory was exciting for her:

Sally: Me extract DNA? Yes that would be great, but I doubt I will ever even see it for real. You need fancy scientific equipment in a sterile lab, you know like on CSI.

Interviewer: Actually that is not quite true. You do see it like that on TV, but there are simple procedures you can do in your kitchen at home, or in the school lab to extract DNA from fruit.

Sally: You're kidding! WOW that's cool. How do I do it? Is it hard? I bet my class won't ever do it – we talk too much so we have to copy notes instead of doing pracs.

Sally's teacher was asked for information on the same two statements:

Mr H: It is easier to deal with ethical concepts through pen and paper worksheets 'cause the kids sit quiet and learn the stuff quietly. If you try to discuss things, there is usually a group who change the topic. So I get them to do worksheets. They seem to like taking notes and reading.

Interviewer: Have you considered extracting DNA with your students?

Mr H: Yes, extracting DNA would be OK I guess. But I don't know how to do it 'cause I don't have time to go to the seminars. They need them during school time not after school when I have other stuff on. I don't know if the kids would be too into it though. The concepts would be tricky I expect, so they may not understand it.

It seems pedagogy, in this case, has a role to play in interests relating to biotechnology. If the task itself is not engaging, then the student is unlikely to engage in the scientific topic. The teachers may not have the discipline knowledge or skills to teach the topic, but may be reluctant to undertake professional development outside of school hours, as in the case of Mr H. Also teachers may perceive some topics to be unnecessarily complex.

Interests in agricultural uses of biotechnology

The potential of agricultural biotechnology is to produce crops resistant to chemicals, pests and diseases; plants with improved post-harvest characteristics; improved diagnosis of plant diseases and the production of high value oil products. As a result of the economic implications of agricultural biotechnology, statements relating to agricultural issues were included in the questionnaire.

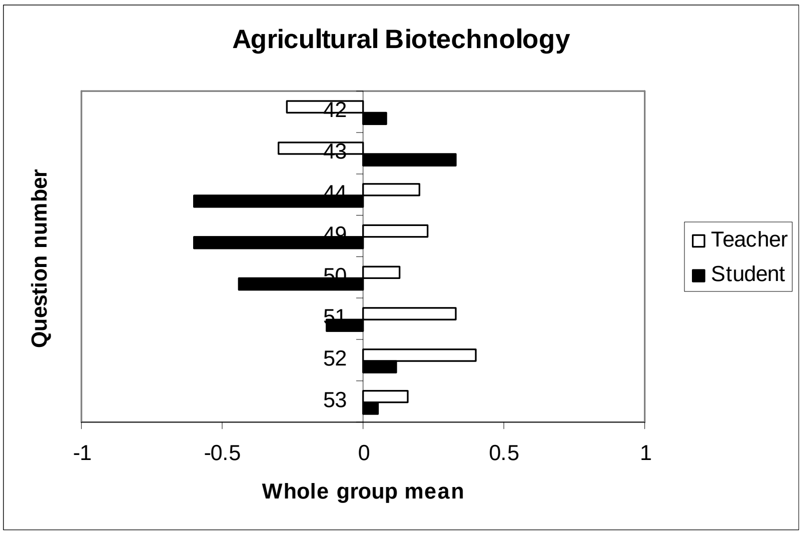
In terms of agricultural biotechnology issues, student and teacher interest varies greatly. 50% of students indicated an interest in investigating cholesterol and saturated fats on health, as compared to 13 % of teachers interested in teaching these topics. In fact nearly half of the teachers expressed a disinterest in teaching these topics. A similar trend was evident relating to the procedures for producing genetically modified organisms. This is shown graphically in Figure 2 . Student statements 49 and 50 relate to insect damage and genetically modified crop pollen respectively. It is clear that the vast majority of students are not interested in studying these topics, yet teachers are interested in teaching it. Teachers are also clearly more interested in presenting lessons on insecticides and genetically modified crops, than students are in studying these topics.

One teacher explained she would be interested in teaching about insect damage to crops:

Mrs P: Well it is an easy concept for the kids to understand. Insects use their mandibles to munch away at a food crop. It is described in lots of books. I think we have a video on a locust plague as well, so I can get them to take notes from the text or video.

One of Mrs P's students however was not interested in studying insect damage:

Tahlia: Well, we know insects destroy crops, you know, like a mouse plague as well. It has something to do with drought as well. I don't know really, but it is boring. You would just take notes as there wouldn't be a prac in it – we cannot make an insect eat something in class.



Note: As the mean approaches a value of 1 it indicates affirmation of the statement, and as the mean approaches -1 it indicates rejection of the statement.

Figure 2. Whole group mean scores for interests relating to agricultural biotechnology

One student was astute to notice that whilst some topics may be boring, they are also of potential interest (Statement 52 (69)):

Mark: Well I think GM food is not good for me. It might change my DNA or something. I don't really know much about it, but it might be interesting.

Interviewer: Might be interesting? Can you explain this last bit?

Mark: Yea, interesting. Not the GM food – that's bad and boring, it doesn't deserve attention – but the way it could affect me or my health would be good to know. I am interested in me, not GM food, but maybe if it affects me. Does that make it clear? I am a bit confused 'cause it is a hard thing to describe. I am interested in ME, what will it do to ME.

Mark's teacher indicated he was not interested in teaching the impact of genetically modified crops on the environment and on our health because:

Mr H: It is not all in the text books yet. Yes I can imagine or hazard a guess about what the impact would be on the environment, but I don't know about the human implications. No one knows, so I could teach the wrong thing if it's not in the book.

Once again it seems pedagogy has a role to play in interests relating to biotechnology. Students do not appear to enjoy lessons or topics which involve note copying, yet teachers appear to consider a topic to be of interest or 'teachable' if the worksheet or video mode of teaching is appropriate. It is also evident that some students have the ability to discern the pedagogy a teacher will use for a given topic. For example, Tahlia assumed (possibly correctly) that her teacher would use note taking for some topics, and practical lessons for other topics.

Interests in human uses of biotechnology

Figure 3 indicates that both the students and the teachers are ambivalent about their interests in studying and teaching the different purposes of genetic testing and gene therapy (Item 55(74)). However, student item 56 indicates a phenomenal 94% of students are interested learning about gene profiling for paternity testing. This is compared to 21% of teachers wanting to teach this topic. Paternity issues are of major interest to students. When asked why, one student explained:

Simon: Well I am kinda curious why it takes so long to do the tests. On the news you hear about a lot of forensic stuff and drug tests taking weeks to get a result back, so paternity would be the same. But like of the TV shows from America, their tests only take over night. Also I am interested in what happens after a kid finds out dad is not really dad. I know a guy who has a step-dad, but that is different I think.

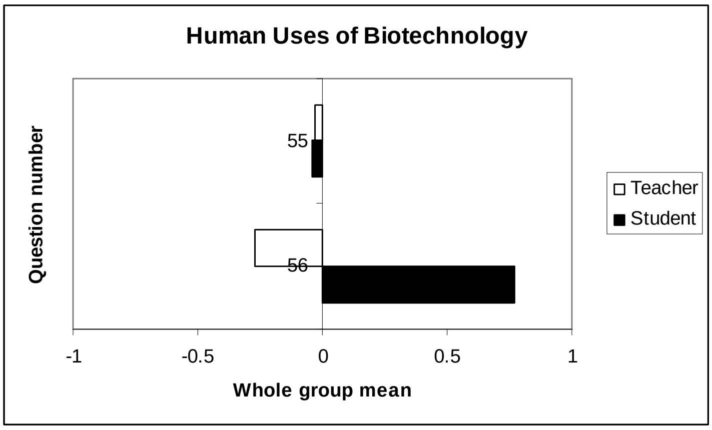
This curiosity is not shared by the teachers. Very few want to teach paternity issues. Three teachers were interviewed and they all indicated they were uncomfortable discussing paternity because some child may find out something they shouldn't:

Mrs P: It's the same as genetics in a way – volatile ground potentially. I once had a class go home to investigate eye colour in parent's and siblings – extended family as well. Anyway one boy had brown eyes, and went home to find mum and dad had blue and green eyes. Now in class we had gone through dominant and recessive genes. This boy took his knowledge home to do the homework task. Well, to cut a long story short, there were all sorts of troubles and a divorce. Never again!

Mr H: No, too messy. I just stick to what's in the text book. You need to be careful or you could be in trouble.

Miss A: It is a very private area. I don't have the skills to sort out class discussion as I am not all that much older that the kids. Students might want to drift onto discussion on multiple partners, then how I answer might tell them my values or preferences. I blush too easily.

These teachers do not want to be the catalyst in a paternity case, so they shy away from the topic. Teachers may also see paternity as equivalent to genetics, and as a personal issue.



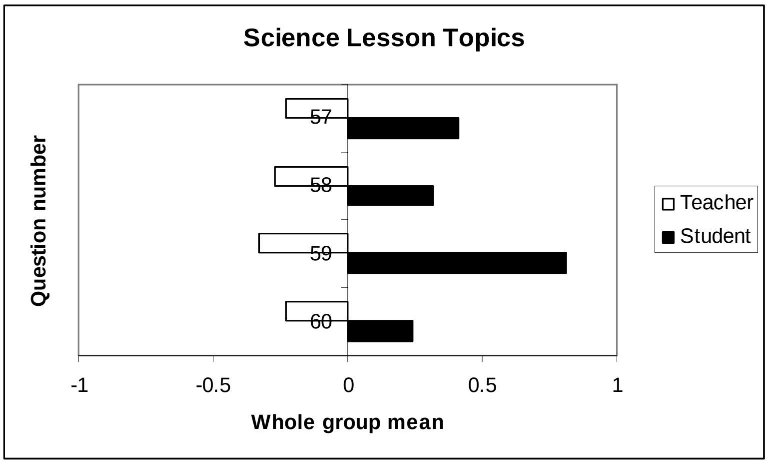
Note: As the mean approaches a value of 1 it indicates affirmation of the statement, and as the mean approaches -1 it indicates rejection of the statement.

Figure 3. Whole group mean scores for interests relating to human uses of biotechnology

Simon, the student curious about forensic time delays, is interested in paternity. However he does not appear he is interested in paternity issues to find out if his family has secrets. His interest is born from what he hears or sees on the television, and so he is grappling to understand procedures as well as implications.

Science lesson topics

Figure 4 shows the results of the student and teacher responses as to what biotechnology topics should be taught in our classrooms. The wording of each statement in this factor differed from all other statements in that specific reference was made to science lessons, thus anchoring each topic to the curriculum. In other factors, the teacher statements were only suggestive in this respect – alluding to the teacher's interest in teaching the topic. In this factor, the students and teachers were required to consider whether or not a topic should be included in their lessons, irrespective of their personal interest in the topic.



Note: As the mean approaches a value of 1 it indicates affirmation of the statement, and as the mean approaches -1 it indicates rejection of the statement.

Figure 4. Whole group mean scores for science lesson topics concerning biotechnology

Once again the students and teachers are opposed. Students feel bioethics, prenatal testing and human cloning should all be included in their science lessons. It is worth noting that all students thought birth control should be included in science lessons. Teachers generally opposed the inclusion of all four topics especially statement 59 (79) relating birth control and its associated issues.

70% of Year 11 students declared an interest in having bioethical topics presented in the classroom:

Simon: Bioethics, yea, they are everywhere, like on the news, TV shows and in the papers. I saw a cool episode once on 'House' where the team had to decide to do an emergency op not in the theatre 'cause another person also needed the operating theatre. Doctors have to make decisions like that all the time so we should be able to do debates and stuff like that too….. Lessons would be more interesting if they were gory and real.

As Simon's teacher indicated:

Mr H: I don't want to cover such things. There is a possibility that someone may be offended by another's views, discussions could become a debate, and it is the English teacher's job to do debates, not mine.

Similar patterns can be found in the responses to statement 58 (78) relating to prenatal testing. The majority of teachers do not want to teach prenatal testing:

Mrs P: I don't like the idea of a woman knowing her unborn child has a problem, and then her choosing a termination. What if the father didn't want to terminate? We then have a problem. No, ethically I don't like it. I don't think the students should have to explore such things. It isn't really relevant to them at the moment. Besides, it isn't in our text book I don't think.

An examination of Figure 4 indicates that the students and teachers surveyed have very different ideas of what topics are of interest for inclusion into biology lessons. This opposition of interests is responsible for at least 1 student reconsidering his enrolment in the subject:

Paul: This subject is boring. If I had known we would not be doing cool stuff like CSI, I wouldn't have done biology. I am going to drop it next term and do something else.

Interviewer: Why is biol so boring? Is it the topics or what?

Paul: All the teacher does is text book stuff like study questions and stuff. We do an experiment once in a while if we are good, but sometimes they don't work out like they should.

Summary

It is well known that students are not selecting the sciences in post compulsory schooling, and this has had a flow-on effect into tertiary studies. There have been a number of explanations posited for this demise in science interests; however, very few if any have explored the link between teacher and student interests. It is obvious from these factors, that the students and teachers have opposing interests. The teachers are not interested in providing lessons on the same topics students are interested in learning about.

An examination of the interests across the factors gives rise to two interesting observations. Firstly, students are interested in topics that have a perception of personal relevance as the topic relates to their health and well being as indicated by the comments from the students above. Students are also interested in topics where there is a perception it may involve practical hands-on activities. Students also seem to have the ability to predict how a topic will be 'taught' by their teachers, and this prediction is enough to prevent some students from engaging with their lessons. Secondly, teachers have interests in topics that are available in print material or video format. They appear to be interested in teaching topics that lend themselves to worksheets and note taking. They tend not to be interested in biotechnology topics that have an element of risk or involve practical work. Teachers also have the perception that some aspects of biotechnology may be too difficult for the student, on the basis that the teacher themselves does not have the knowledge.

In Queensland this is problematic, as the teachers design the curriculum for their particular students. It seems teachers do not want to get involved in controversial issues, and they do not want to present topics not found in the text book. Students, on the other hand want to explore ethical concerns. They watch shows on the television, consider this material to be ‘real’, and desire to do hands-on practical work. One student enrolled in biology in a post compulsory classroom, but found his interests not being met. He planned to withdraw from the study of biology at the first opportunity. The student did not know what subject he would enrol in after biology, except that he knew “it wouldn’t be a science subject” (Paul). It is unknown how widespread this ‘lack of interest’ causing departure from a science subject is.

Implications for curriculum developers

Students have well developed ideas of what is of interest and what is not. Teachers and curriculum designers should be encouraged to determine these interests and to relate the interests to subject matter to provide a base for new knowledge. “Student voice” needs to have greater prominence in the design of our science curriculum. At present it is the adults who design the curriculum based on adult notions of what is of interest to students. Teachers also need to consider the appropriateness of their selected pedagogy. This system is failing our students, and they are choosing not to do further study in the sciences beyond the compulsory years. Therefore, more emphasis needs to be placed on what students are interested in, and having this incorporated into a curriculum which serves the student.

In a recent OECD forum, student science and technology interests were discussed. It was noted that teaching often focuses on memorising rather than on understanding, and heavy workloads leave little time for experiments. It was highlighted that students need to feel the relevance of the subject to society and to their own world, but in reality what is taught is often disconnected from cutting-edge science and from today’s applications of science and technology, and tends to dampen interest. A recommendation of particular interest is that curricula should be redesigned to better reflect the reality of modern science and technology, and to emphasise their contributions to society. Specific actions can focus on encounters with science and technology professionals, exposure to cutting-edge science and technology and their applications in modern life, debates on the role and social relevance of science and technology, and actions directed towards a “humanisation” of science teaching (OECD, 2006).

References

Aikenhead, G. (2006). *Science education for everyday life*, New York:Teachers’ College Press.

Ajzen, I. & Fishbein, M. (1980). *Understanding attitudes and predicting social behaviour.* New Jersey: Prentice Hall.

Atwater, M.M., Wiggins, J., & Gardner, C.M. (1995). A study of urban middle school students with high and low attitudes toward science. *Journal of Research in Science Teaching*, *32*(6), 665-677.

Baram-Tsabari, A., Sethi, R. J., Bry, L., & Yarden, A. (2006). Using questions sent to an ask-a-scientist site to identify children’s interests in science. *Science Education* DOI 10.1002/sec.

Benbow, C.P., & Minor, L.L. (1986). Mathematically talented males and females and achievement in the high school sciences. *American Educational Research Journal, 23,* 425-436.

Curriculum Corporation. (2001). Biotechnology Online. http://www.biotechnologyonline.gov.au/. Accessed July 3, 2006.
Chambers, K. & Andre, T. (1997). Gender, prior knowledge, interest, and experience in electricity and conceptual change text manipulations in learning about direct current. *Journal of Research in Science Teaching, 34*(2), 107-123.
Chen, S-Y., & Raffan, J. (1999). Biotechnology: Student's knowledge and attitudes in the UK and Taiwan. *Journal of Biological Education*, 34, 17-23.
Dawson, V. & Schibeci, R. (2003). West Australian high school students' attitudes towards biotechnology processes. *Journal of Biological Education*, *38*(1), 7-12.
Dawson, V. & Taylor, P. (2000). Teaching bioethics in science: Does it make a difference? *Australian Science Teachers' Journa*l, *45*(1), 59 – 64.
Fishbein, M. & Ajzen, I. (1975). *Belief, attitude, intention and behaviour: An introduction to theory and research.* Reading, MA: Addison-Wesley.
Gunter, B., Kinderlerer, J., & Beyleveld, D. (1998). Teenagers and biotechnology: A survey of understanding and opinion in Britain. *Studies in Science Education*, *32*, 81 – 112.
Haladyna, T. & Shaughnessy, J. (1982). Attitudes towards science: A quantitative synthesis. *Science Education, 66*, 547-563.
Hewson, P.W., Kerby, H.W., & Cook, P.A. (1995). Determining the conceptions of teaching science held by experienced high school teachers. *Journal of Research in science Teaching, 32*, 503-520.
Jenkins, E.W. & Pell, R.G. (2006). Me and the environmental challenges: A survey of English secondary school students' attitudes towards the environment. *International Journal of Science Education*, *28*(7), 765-780.
Kahle, J.B., & Meece, J. (1994). Research on gender issues in the classroom. In D.L. Gabel (Ed.), *Handbook of research on science teaching and leaning* (pp. 542-558). New York: Macmillan.
OECD, (May, 2006) Organisation for Economic Co-operation and Development Global Science Forum Evolution of Student Interest in Science and Technology Studies Policy Report http://www.oecd.org/dataoecd/16/30/36645825.pdf#search=%22science%20attitude%20interest%20defined%22 Accessed August 27, 2006.
Olsher, G. & Dreyful, A. (1999). The 'ostension-teaching approach as a means to develop junior-high student attitudes towards biotechnologies. *Journal of Biological Education*, *34*, 24 – 30.
Osborne, J., & Collins, S. (2001). Pupils' views of the role and value of the science curriculum, *International Journal of Science Education, 23(5*), 441-467.
Pintrich, P.R., & Schunk, D.H. (2002). Motivation in education: Theory, research, and applications (2nd ed.). NJ: Merril.
Prenzel, M. (1998). Interest research concerning the upper secondary level, college, and vocational education: An overview. In L. Hoffmann, A, K. Krapp, A. Renninger, & J. Baumert (Eds.), Seeon conference on interest and gender (pp. 355-366). Keil, Germany:IPN.
Queensland Studies Authority. (2004). Senior Biology Syllabus, Brisbane Queensland Australia.
Schibeci, R. (2000). Students, teachers and the impact of biotechnology in the community. *Australian Science Teachers' Journa*l, 46, 27 – 33.
Simpson, R.D., Koballa, T.R., Oliver, J.S., & Crawley, F.E. III. (1994). Research on the affective dimension of science learning. In D.L. Gabel (Ed.), *Handbook of research on science teaching and leaning* (pp. 211-236). New York: Macmillan.
Simpson, R.D. & Oliver, J.S. (1990). A summary of major influences on attitude toward and achievement in science among adolescent students. *Science Education, 74,* 1-18.

Skamp, K., Boyes, E., & Stanisstreet, M. (2004). Students' ideas and attitudes about air quality. *Research in Science Education, 34*(3), 313-342.
Steele, F., & Aubusson, P. (2004). The challenge in teaching biotechnology. *Research in Science Education, 34*(4), 365-387.
Zacharia, Z. (2003). Beliefs, attitudes, and intentions of science teachers regarding the educational use of computer simulations and inquiry-based experiments in physics. *Journal of Research in Science Teaching, 40*(8), 792- 823.

Appendix - Student Questionnaire

SA	If you *strongly agree* with the statement
A	If you *agree* with the statement
N	If you *neither agree nor disagree* with the statement or are not sure
D	If you *strongly disagree* with the statement
SD	If you *strongly disagree* with the statement

26.	I would be interested in testing a range of natural products (natural antibiotics) to find out how effectively they kill bacteria.	SA	A	N	D	SD
27.	I would like to investigate different media articles on the ethics involved in biotechnology when using animals.	SA	A	N	D	SD
28.	I would like to actually extract DNA myself.	SA	A	N	D	SD
29.	Investigating the altering of human gene codes to reduce human genetic disorders would be interesting.	SA	A	N	D	SD
30.	I would be interested in studying the process of identifying sequences of DNA.	SA	A	N	D	SD
31.	I would like to produce my own clone of a plant by tissue culture.	SA	A	N	D	SD
32.	I am interested to learn more about ways to control / eradicate pests (e.g. the fox, cane toad, or minor bird) harmful to the Australian environment.	SA	A	N	D	SD
33.	I would like to investigate the harmful effects of genetic engineering on our environment.	SA	A	N	D	SD
34.	I would like to know more about the implications of releasing a genetically altered organism into the environment.	SA	A	N	D	SD
35.	I would like to know why we are bothering to save the bilby.	SA	A	N	D	SD
36.	I would like to examine the decisions involved when saving species considered as most important to save.	SA	A	N	D	SD
37.	I would like to know how biotechnology can help metabolise oil slicks and other wastes.	SA	A	N	D	SD
38.	I would be interested in understanding why there is such an interest in cloning the thylacine (Tasmanian Tiger).	SA	A	N	D	SD
39.	I would like to know what issues influence the decisions made to conserve particular plants or animals.	SA	A	N	D	SD
40.	I am interested in investigating the effect of cholesterol and saturated fats on my health.	SA	A	N	D	SD
41.	I am interested in investigating the effect individual foods like genetically modified canola have on my health.	SA	A	N	D	SD
42.	I am interested in studying the effect of weeds in Australia.	SA	A	N	D	SD
43.	Investigating the steps that scientists usually follow to produce a genetically modified organism is of interest to me.	SA	A	N	D	SD
44.	I would like to explore the concerns or opinions that people may have regarding the growing genetically modified canola in Australia.	SA	A	N	D	SD
45.	I would like to know what the experts think about labelling of genetically modified foods.	SA	A	N	D	SD
46.	I think it is important that I understand the information that can be found on food labels.	SA	A	N	D	SD
47.	I would like to know more about biotechnology to form an understanding whether I would feel, and be safe to eat genetically modified food.	SA	A	N	D	SD
48.	I would like to see non genetically modified farming continued so that I can have a choice as to what I eat.	SA	A	N	D	SD
49.	I am interested in finding out the extent of insect damage to the Australian	SA	A	N	D	SD

	cotton crops and ways of controlling it.					
50.	I am interested to find out whether the pollen from genetically modified plants is responsible for killing Monarch butterflies.	SA	A	N	D	SD
51.	I am interested in finding out how scientists have been able to develop genetically engineered cotton that produces its own insecticide.	SA	A	N	D	SD
52.	It is important that I understand issues relating to the impact genetically modified crops have on the Australian environment and on our health and well-being.	SA	A	N	D	SD
53.	I would like to know more and be responsible for formulating my own personal understanding and opinion whether genetically modified organisms are good or bad for the environment.	SA	A	N	D	SD
54.	I would like to know from who and how foods in Australian supermarkets (and other food outlets) get their approval.	SA	A	N	D	SD
55.	I would like to investigate the different purposes of genetic testing and gene therapy.	SA	A	N	D	SD
56.	I am interested in studying the issues involved in the use of gene profiling for paternity testing (identifying the biological father).	SA	A	N	D	SD
57.	Bioethics education should be discussed in science lessons.	SA	A	N	D	SD
58.	Prenatal testing and the issues associated with it should be discussed in science lessons.	SA	A	N	D	SD
59.	Birth control and the issues associated with it should be discussed in science lessons.	SA	A	N	D	SD
60.	Human cloning and the issues associated with it should be discussed in science lessons.	SA	A	N	D	SD