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# MALAYSIAN SECONDARY SCHOOL STUDENTS' KNOWLEDGE AND ATTITUDES TOWARDS BIOTECHNOLOGY

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## Introduction

Biotechnology is a science and technology field which shows a rapid development in the 21st century. Malaysia is one of the countries in this world that is interested in utilizing biotechnology to propel the economy towards high income economy. Science education has an important role to play in producing human resource and skills for the biotechnology field in this country to achieve its success (Malaysia, 2006).

However, Malaysia needs to be prepared in facing issues that are related with biotechnology development (Firdaus-Raih et al, 2005) such as importing and consuming genetically modified soy beans. The society's view and opinion towards genetically modified products need to be taken into account because the society's perception, knowledge and acceptance of genetically modified organism (GMO) determines if the commercializing process and its usage can be done (Kamaldeen & Powell, 2000). Latifah et al. (2006), investigated the society's attitude towards modern biotechnology, involving respondents who were 18 years old and above. Some other studies such as Nor Arizah (2008), studied the level of understanding and attitude of agriculture teachers towards biotechnology usage in farm plantation; and also Nur Aziera et al. (2009), who did a study on university students' attitude model development toward Genetically Modified Food (GMF).

So far, studies in Malaysia on biotechnology only focused on adults and beyond but due to the rapid expansion of the field; it is equally an important issue to be exposed to the teenagers especially secondary school students. Students' knowledge and attitude towards biotechnology are important because students are the future leaders of the country, policy-makers, decision-makers and also the future consumers. There are a few studies relating to the

**Abstract.** *The purpose of this research is to investigate secondary students' knowledge and attitude towards biotechnology and its application. A questionnaire was administered to 214 (16 years old) students who are either taking Biology or General Science. The questionnaire contained 15 items measuring students' knowledge and also 28 items measuring students' attitude towards biotechnology. The students' level of knowledge is high but limited only to medical issues. Students showed positive attitude towards biotechnology applications that are related to medical and economic purposes. However, students are unaware of ethical issues related to biotechnology applications. The t-test showed that there was no significant difference of students' knowledge of biotechnology in terms of gender. However, there was a significant difference in terms of students' attitude towards biotechnology between Biology and General Science students. These findings serve as initial input of Malaysian secondary students' knowledge and attitudes towards biotechnology and its application.*

**Key words:** *attitude, biotechnology, knowledge, secondary school, survey.*

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students' knowledge and attitude towards biotechnology that have been carried out in abroad since 1990 and these studies are still carried on due to rapid development of biotechnology (Lock & Miles, 1993; Chen & Raffan, 1999; Dawson & Shibeci 2003a, 2003b; Cavanagh et al., 2005; Dawson 2007; Prokop et al., 2007; Murat et al. 2009). The findings of the studies generally showed that there are varied level of students' knowledge towards biotechnology and its application. In terms of students' attitude towards biotechnology, previous studied showed that students' attitude would depend on the issues related to biotechnology and the context where the biotechnology techniques are applied.

The importance of the study regarding students' knowledge and attitude towards biotechnology can be seen through a few studies carried abroad. In the United Kingdom, Lock and Miles (1993) carried out a study among the school students to find out the students' level of knowledge and attitude towards biotechnology and genetic engineering. Also, there was a large wide survey done to find out teenagers' opinions in Britain towards issues and matters that are related with Biotechnology field (Gunter et al., 1998). Other than that, there was one specific study by Hill et al. (1998) that explore the students' conventional ideas regarding the application of genetic engineering in food processing.

Together with the development of biotechnology field in that country, researchers in Australia also conducted studies regarding the students' knowledge and attitude towards biotechnology. Among the studies done, were surveys to find out the level of knowledge (Dawson & Shibeci, 2003a) and also attitude (Dawson & Shibeci, 2003b) of the students in West Australia towards biotechnology. Next, there was also a study (Cavanagh et al., 2005) to find out the students' opinion in rural areas of Riverina, New South Wales towards biotechnology. Following by this, a further study was carried out by Dawson and Soames (2006) to determine the effects of biotechnology education towards the students' knowledge and attitude towards biotechnology processes after the education that the high school students in West Australia have received. Other than that, Dawson (2007) also carried out a study to find out students' progress regarding their knowledge and attitude towards biotechnology process, involving students from different levels of age starting from age 12 to 17.

There were a few similar studies that were carried out in other countries, for example there was a case study done to find out students' attitude towards modern genetic and biotechnology among the high school students in Brazil (Massarani & Moreira, 2005). Also, there were studies carried out to explore students' attitude towards modern biotechnology in the Netherlands (Klop & Severiens, 2007). Researchers in Spain also did a study to gather students' opinion related with biotechnology to determine the values that were suitable to their society (Saez et al., 2008). A similar study was also made to find out the level of students' knowledge and attitude towards genetic engineering in Ankara, Turkey (Bal et al. 2007) and Lithuania (Lamanauskas & Makarskaite-Petkeviciene, 2008), which was involving university students.

Based on those previous researches, it appears that there exists a similar trend in the findings and results of the studies although the studies used different instruments. Studies carried out in the UK showed that a high number of high school students do not understand about biotechnology's processes and its implication (Lock & Miles, 1993; Gunter et al., 1998). For example Lock and Miles's study showed that one-third of 188 samples didn't know what are biotechnology and genetic engineering; and almost half of the study samples was unable to give examples related to either biotechnology or genetic engineering. These showed that the high school students' level of knowledge regarding biotechnology was low. The same finding obtained from the study that involved 1116 of 15 years old students that showed that almost one-third of the students had a little or no knowledge about biotechnology (Dawson & Shibeci, 2003a). On the other hand, Dawson's study finding showed that students' ability to state out general definition and examples regarding biotechnology, cloning and GMF was relatively weak among the students aged 12 to 13 years old but it showed an increase among the elder students. However, Cavanagh et al. (2005) study showed that at least two-third of the students had good knowledge regarding medical biotechnology issues.

Studies on students' attitude towards biotechnology also showed that there was a similar trend among the various studies. Students' attitude towards biotechnology and genetic engineering was seen to depend on the context. This was according to the study made in the UK that showed almost all of the students involved disagreed or less agreed if there was animal used in the biotechnology process



or genetic engineering, especially among the female students (Lock & Miles, 1993). The same findings obtained in Dawson (2007) study that was carried in Australia, showed that the majority of the students agreed that the usage of biotechnology process which involved microorganism, plants and human but they did not agree if animals were used. Gunter et al. (1998) study showed most of the teenagers aged from 16 to 19 years old in the UK believed that the advantages obtained from different biotechnology applications would be able to overcome the risks faced. The study which studied teenagers' opinions towards GMF showed almost 6 out of 10 teenagers stated that the public needed to be provided more information regarding biotechnology field. On the other hand, the attitude of 1116 students in West Australia aged from 15 to 16 years old showed a wide range of agreement regarding the acceptance of biotechnology applications (Dawson & Shibeci, 2003b).

Issues related to knowledge and public attitude towards biotechnology and modern genetic are seen as a stake to be highlighted in many countries and they become objects in many studies whether in quantitative or qualitative method. In Malaysia, biotechnology field is rapidly developing but studies related with society's knowledge, attitude, acceptance and perception are still consider less in numbers and insufficient for the moment. There were only a few studies carried out by Latifah et al. (2006), University of Illinois at Urbana Champaign and International Service for the Acquisition of Agri-Biotech Applications (UIUC-ISAAA) (2003), Nor Arizah (2008) and Nur Aziera et al. (2009) that involve adult group as respondents aged from 18 years old and above. Most of the respondents were manufacturers, scientists, policy-makers, non-government organizations (NGO), media, politicians, religionist, university students and the public.

Since Malaysia has identified the biotechnology field as one of the national economy generators at present and future, therefore it is a must for the responsible parties to be aware of the society views and acceptance towards all the issues that emerged in this field. Although there were already studies that have been carried out involving adult groups, however it is still consider not enough because there is still insufficient of similar study involving school students. Such study need to be carried out because the result and finding will reflect the view or opinion for the students in present days, who will be leaders, policy-makers, consumers and the society of the country future towards the issues that are related with biotechnology in future.

Therefore, the study related with students' knowledge and attitude towards biotechnology is consider as an important matter to be explored because it is able to provide information about the status of students' knowledge and attitude in this country towards biotechnology and its application in general. Thus, this study is carried out to determine the students' level of knowledge and attitude towards biotechnology especially upper form school students.

#### *Purpose*

The study is carried to identify the knowledge and attitude of form four (16 years old) secondary school students in one of the states in Malaysia towards biotechnology and its application. The research questions were: What is the students' level of knowledge and attitude towards biotechnology and its application? What is the difference between the level of knowledge and attitude of students towards biotechnology based on the gender and subjects that students have taken?

#### **Methodology of Research**

##### *Sample*

This study has been carried out using the descriptive research design. The sample was chosen based on the stratified random sampling method to ensure that the sample represents the population of the study. The study has been carried out among six secondary schools and a total of 214 students were involved in the study in which 99 were male and 115 female students. 106 of them took Biology and another 108 students follow General Science.



*Instrument*

A survey questionnaire consisted of 43 items using a Likert scale within scale 1 (very disagree) to scale 5 (very agree) was administered to the sample. There were 15 items related to knowledge of Biotechnology (Biotechnology Knowledge Questionnaire (BKQ)) used to measure the level of students' knowledge towards biotechnology and its application. Another 28 items were used to measure students' attitude towards biotechnology and its application (Biotechnology Attitude Questionnaire (BAQ)).

The questionnaire adapted from Prokop et al. (2007) and Erdogan et al., (2009). The questionnaire was translated and modified to Malay Language and has been tested its validity through face validity by two raters who were experienced teachers who taught Biology and General Science subjects. To ensure the originality meaning of each item, the questionnaire that has been given to the respondents were all in bilingual form.

Before the instrument is used for the actual study, a pilot study was conducted in order to test the reliability of the instrument (Nunally and Bernstein, 1994). The Malay Language version of the BKQ and BAQ was tested to a group of students with a similar characteristic with the sample of the present study. The reliability of both instruments was computed using the Cronbach Alpha to examine internal consistency of the instruments for each sub-scale. The BKQ and BAQ reliability index as shown in Table 1. The Cronbach's alpha value of this study was in the range of the Cronbach's alpha values obtained in Prokop et al. (2007), Erdogan et al. (2009), Murat et al. (2009) and Usak et al. (2009) studies as comparison.

**Table 1. Reliability of the BKQ and BAQ questionnaire.**

Aspects/ Constructs measured	Number of items	Reliability ( $\alpha$ )
Knowledge	15	0.67
Overall attitude	28	0.64
Dimension of attitude:		
Factor 1. Consumption of GM products (CGMP)	4	0.67
Factor 2. GM in agro industry (GMAI)	5	0.82
Factor 3. Public awareness of GMO (PAGMO)	3	0.61
Factor 4. Shopping of GM products (SGMP)	6	0.68
Factor 5. Ethics of genetic modifications (EGM)	3	0.79
Factor 6. Ecological impact of genetic engineering (EIGE)	4	0.66
Factor 7. Use of genetic engineering in human medicine (UGEHM)	3	0.67

*Data Analysis*

The response that shows either high level of biotechnology knowledge or positive attitude towards biotechnology applications will yield a mean of 3.0 or more. For an item that is phrase in a negative form, the data will be reverse code first before obtaining its mean value. In an effort to gain students' level of knowledge and attitude towards biotechnology and its applications, the main data analysis procedure involved is the descriptive analysis, which focuses on the mean value. In this case, the mean and the standard deviation were computed for each of the sub-scales and the total score to provide the knowledge and attitudinal profile. An independent t- test analysis on the knowledge of biotechnology and their attitudes toward biotechnology and its applications was performed to determine whether the students' gender and exposure to General Science or Biology course impacted on their level of biotechnology and attitude towards its applications.



## Results of Research

### *Students' Knowledge of Biotechnology and Its Application*

As shown in Table 2, overall, students' level of knowledge of biotechnology and its application is high (mean=3.279) However, students only have certain knowledge related with biotechnology and its application as shown in the mean value that is beyond 3.0 as indicated in 10 of the 15 items (items 1,2,3,4,7,8,9,12,13). For example, students show a high level of agreement (mean= 3.617) that a genetically modified (GM) crops can increase the productivity and resistance of crops towards diseases. Students tend to show a good level of biotechnology and its application that are related to everyday situations e.g. a) GMO that can be used for medical purposes, b) GM crops that can increase the nutrition quality and taste of the fruits as well as developing traits to last longer during delivery process, and c) genetically modification can invent food with high nutrition value and vitamin.

Students seem to show less understanding in items that are related to application of biotechnology that are abstract and not directly related to them. For example a) genetically modification is animal torturing (mean=3.000), b) eating GMF can spoil human genes (mean= 2.981), and c) GM crops are infertile (mean=2.888).

**Table 2. Mean score and standard deviation of knowledge towards biotechnology and its application items.**

No.	Item	Mean	S.D.
1.	Practical application of GM plants may increase productivity and resistance of plants against diseases.	3.617	0.994
2.	Manipulation with DNA changes genes of GM organisms.	3.533	0.977
3.	Application of GM methods on animals can increase animal resistance against diseases.	3.449	1.014
4.	GM organisms are used in medicine (e.g.: insulin production with GM microorganisms).	3.523	1.005
5.	Genetical modification is painful for animals.*	3.000	1.267
6.	GM organisms contain many dangerous chemicals.*	3.051	1.101
7.	Genetical modification to plants can increase nutritional quality and flavour of fruits and develops traits to withstand shipping process.	3.537	1.177
8.	Foods with increasing nutritional value and vitamins can be created through genetic modification.	3.528	0.953
9.	Microbes should be genetically engineered to make them more efficient at decomposing human sewage.	3.224	1.028
10.	Consumption of GM food can destroy human genes.*	2.981	1.134
11.	GM organisms are always bigger than normal.*	3.135	1.046
12.	It is possible to transfer genetic material between dissimilar organisms, such as animals and plants, because DNA is chemically identical.	3.187	1.148
13.	GM modification of poultry results in greater proportion of lean.	3.280	1.019
14.	GM crops are sterile.*	2.888	1.099
15.	Recombinant bovine somatotropin is an animal drug that increases milk produced by dairy cows.	3.252	0.960
<b>Overall level of knowledge</b>		<b>3.279</b>	<b>0.426</b>

Note: \* Item was in negative form, the inverted score procedure was used.



*Students' Attitude towards Biotechnology and Its Application*

Overall the students showed neutral attitude towards the consumption of genetically modified products (CGMP) (see Table 3). Students were found to show neutral attitude towards two out of four items related with CGMP while showed negative attitude towards the rest of the two items namely they think that consumption of GMF is risky and they will not give GMF to children.

**Table 3. Mean score and standard deviation of dimension/ factor attitude towards consumption of genetically modified products (CGMP) items.**

No.	Item	Mean	S.D.
1.	Altering the genes in fruit to improve their taste is not acceptable to me.*	3.079	1.255
2.	I am against altering the genes of fruits and vegetables to make them stay fresh longer.*	3.033	1.272
3.	Consumption of genetically modified food is risky.*	2.776	1.077
4.	I would not give GM food to children.*	2.701	1.107
<b>Overall Attitude towards CGMP</b>		<b>2.897</b>	<b>0.780</b>

Note: \* Item was in negative form, the inverted score procedure was used.

As shown in Table 4, overall students showed a positive attitude towards genetically modification in agro industry (GMAI). Students showed extremely positive attitude towards the application of genetic engineering if it helps with therapy of genetically determined diseases and they were interested to know more about GMF.

**Table 4. Mean score and standard deviation of dimension/ factor attitude towards genetically modification in agro industry (GMAI) items.**

No.	Item	Mean	S.D.
1.	I agree with the use of genetic engineering if it helps with therapy of genetically determined diseases.	3.855	1.008
2.	I support the use of food biotechnology to modify plant's genetic structure to be more resistant to damage by insects, thereby reducing pesticide applications.	3.472	1.161
3.	Altering the genes of plants so that they will grow better in salty soils is acceptable to me.	3.416	1.048
4.	I agree with the use of plants in which genes increasing quality and productivity were inserted.	3.486	1.137
5.	I want to know more about genetically engineered foods.	3.724	1.123
<b>Overall Attitude towards GMAI</b>		<b>3.591</b>	<b>0.755</b>

Students' overall attitude towards public awareness of GMO (PAGMO) is also positive (see Table 5). Students showed positive attitude and trust that the food industry will take necessary actions to provide safe GMF and they think that the current governmental regulations are sufficient to protect the public from risks associated with GMF. However, students are uncertain or doubt if the public is sufficiently informed about risks associated with GMF.



**Table 5. Mean score and standard deviation of dimension/factor of attitude towards public awareness of genetically modified food (PAGMO) items.**

No.	Item	Mean	S.D.
1.	I trust the food industry to take necessary actions to provide safe genetically engineered foods.	3.757	1.060
2.	I think current governmental regulations are sufficient to protect the public from risks associated with genetically engineered foods.	3.304	1.220
3.	Public is sufficiently informed about risks associated with genetically engineered foods.	3.075	1.094
<b>Overall Attitude towards PAGMO</b>		<b>3.378</b>	<b>0.748</b>

With reference to students' attitude towards shopping of GM products (SGMP), it was found to be neutral (see Table 6). Students showed a very prominent negative attitude (mean= 2.757) towards inserting genes from human cells into fertilized eggs of sheep. However, students seem to show positive attitude towards the idea of changing the genes in cattle to make their meat more nutritious to eat.

**Table 6. Mean score and standard deviation of dimension/factor of attitude towards shopping of genetically modified products (SGMP) items.**

No.	Item	Mean	S.D.
1.	Genetically modified food does not influence human health.	3.005	1.098
2.	I would eat genetically modified tomatoes.	3.051	1.180
3.	I think that genetically modified products taste better.	3.103	1.034
4.	If I find that the product is made from genetically modified stuff, I will buy it.	3.051	0.940
5.	Inserting genes from human cells into the fertilized eggs of sheep is acceptable to me.	2.757	1.251
6.	I support changing the genes in cattle to make their meat more nutritious to eat.	3.364	1.117
<b>Overall Attitude towards SGMP</b>		<b>3.055</b>	<b>0.608</b>

Table 7 displays students' attitude towards the ethic of genetic modifications (EGM) and it is found to be neutral. Students showed neutral attitude towards all of the three items, in other words, students were unable to evaluate whether biotechnology applications are ethical.

**Table 7. Mean score and standard deviation of dimension/factors of attitude towards ethics of genetic modifications (EGM) items.**

No.	Item	Mean	S.D.
1.	I am opposed to transfer of genetic material between plants and animals.*	2.916	1.234
2.	Manipulations with DNA are unethical.*	3.005	1.085
3.	Men do not have rights to intervene to DNA, it is against nature.*	3.065	1.193
<b>Overall Attitudes towards EGM</b>		<b>2.995</b>	<b>0.850</b>

Note: \* Item was in negative form, the inverted score procedure was used.

As whole students showed negative attitude towards ecological impact of genetic engineering (EIGE). Students showed negative attitude towards items for example genetic manipulations disturb ecological relationships, and there is a threat of hybridization between genetically modified and normal plants which would endanger original genetic resources of wild plants. However, students showed neutral attitude towards the item of supporting a ban on the production and purchase of GM products (GMP).



**Table 8. Mean score and standard deviation of dimension/factor of attitude towards ecological impact of genetic engineering (EIGE) items.**

No.	Item	Mean	S.D.
1.	We should not alter the genes in plants to get them to make more oils useful in manufacturing.*	2.846	1.142
2.	Genetic manipulations disturb ecological relationships.*	2.598	0.996
3.	There is a threat of hybridization between genetically modified and normal plants which would endanger original genetic resources of wild plants.*	2.519	0.953
4.	I would support a ban on the production and purchase of genetically engineered products.*	3.033	1.188
<b>Overall Attitude towards EIGE</b>		<b>2.749</b>	<b>0.617</b>

Note: \* Item was in negative form, the inverted score procedure was used.

As shown in Table 9, students' attitude towards the use of genetic engineering in human medicine (UGEHM) was positive. This proved that students agreed to all the three items that were related with the attitude towards UGEHM especially for the item that supporting the use of genetic engineering for non food purposes such as production of human medicines.

**Table 9. Mean score and standard deviation of dimension/factor of attitude towards the use of genetic engineering in human medicine (UGEHM) items.**

No.	Item	Mean	S.D.
1.	Use of GM microbes to decomposing human sewage is acceptable to me.	3.402	1.033
2.	I support the use of genetic engineering for non food purposes such as production of human medicines.	3.551	1.081
3.	I agree with production of insulin with using genetically modified microbes.	3.486	1.020
<b>Overall Attitude towards UGEHM</b>		<b>3.480</b>	<b>0.668</b>

#### *The Difference between Students' Level of Knowledge Towards Biotechnology and Its Application Based on Gender and Science Subjects Taken*

The analysis of t-test on the difference between mean scores of students' level of knowledge towards biotechnology and its application based on gender showed no significant difference between the score of male students' knowledge (Mean = 3.227, S.D. = 0.442) and the score of female students' knowledge (Mean = 3.323, S.D. = 0.408;  $t = -1.648$ ,  $df=212$ ,  $p > 0.05$ ). There was also no significant difference found between the scores of students who taken Biology (Mean = 3.320, S.D. = 0.502) and General Science (Mean=3.239, S.D. = 0.332;  $t = 1.398$ ,  $df= 212$ , and  $p > 0.05$ ).

#### *The difference between Students' Attitudes towards Biotechnology based on the factors of Gender and Science Subjects taken*

The t-test analysis was also used to compare the mean of students' attitude towards biotechnology and its application based on gender. There was a significant difference between the score of male students (Mean = 3.148, S.D. = 0.675) and female students (Mean = 2.975, S.D. = 0.535);  $t = 2.087$ ,  $df=212$ ,  $p < 0.05$ ), with male showing more positive attitude towards biotechnology applications. Based on the science subjects taken it was found that there was a significant difference between the mean score of students studying Biology (Mean = 3.220, S.D. = 0.333) and General Science (Mean= 3.097, S.D. = 0.313;  $t = 2.786$ ,  $df= 212$ ,  $p < 0.05$ ).





## Discussion

The development of biotechnology in Malaysia nowadays should be able to change the society's view towards this scientific field. Due to insufficient and lack of related information, society had wrong view and negative opinions towards the biotechnology field. Malaysia society's knowledge can be conclude as low (UIUC-ISAAA, 2003) while from the aspect of awareness about modern biotechnology can be conclude as modest (Latifah et al., 2007). In such situation, it is very important to identify the students in Malaysia regarding their knowledge about biotechnology and its application.

The findings of this study showed that the knowledge level of form 4 students about biotechnology and its application, overall, was considered high. This finding is probably because the students were already taught about biotechnology and its application in the Form 4 Biology and General Science's syllabus (Ministry of Education Malaysia, 2005a, 2005b). In the General Science syllabus, one of the learning areas is on the effects of genetic research in the field of medicine, agriculture as well as the importance of adhering to ethics and morality in genetic research. The Biology syllabus, also, touch on those similar biotechnology topics. Thus, as shown in studies by Lock and Miles (1993), Lock (1994) and Lock et al. (1995), the students' level of knowledge showed a better result after they attended teaching and learning activities related with biotechnology. However, the students' knowledge was limited towards a few aspects or applications in biotechnology, namely related to the field of medicine and agriculture. This finding concurs with what is taught in both the syllabuses.

The study's finding showed that there was no significant difference between the level of knowledge between male and female students. In addition, students who take Biology and General Science also showed that there was no significant difference in terms of their level of biotechnology knowledge. This is as expected since both syllabuses expose to the students on topics related to biotechnology and its applications. It is the aim of science education in Malaysia to promote scientific literacy for all. Thus, students who are not pursuing science as career (e.g. taking General Science) and those who are pursuing science as a career (e.g. majoring in Biology) are subjected to biotechnology and its applications. This finding supported the previous study that showed knowledge level of students who attended or exposed to Biology subject has no significant difference comparing with other students (Lamanauskas & Makarskaite- Petkeviciene, 2008).

When discussing about issues regarding biotechnology and society, other than knowledge, the society's attitude towards biotechnology is often reviewed. Malaysia society showed a moderate stance (UIUC- ISAAA, 2003) and multidimensional attitude towards biotechnology. Overall, the findings showed that students who were involved in this study showed a positive attitude towards biotechnology and its application. However, students' attitude according to the seven factors of attitude towards biotechnology suggested by Erdogan et al. (2009) showed multiple attitudes. For examples, students showed a more positive attitude if biotechnology and its application for medical purposes comparing with other purposes (Chen & Raffan, 1999; Hansen & Nascimento, 2003; Dawson & Soames, 2006). On the other hand, it appears that students' display negative attitude towards certain application of biotechnology for example ecological impact of genetic engineering remain despite attending courses related to biotechnology (Kitto et al., 2003; Dawson & Soames, 2006). Perhaps such issues are not discussed in detail in terms of the advantages and limitations.

Like in the findings of previous studies (Ozden et al. 2008; Murat et al. 2009; Usak et al. 2009) this study also found that there was no significant in terms of students' attitude towards biotechnology based on gender. However, there was a significant difference between students who took Biology and General Science in terms of their attitudes toward biotechnology applications namely relating to 'attitude towards consumption of GM products (CGMP)' and 'genetic modification in agro industry (GMAI)'. This is probably due to the fact those who pursue science as a career, in this study are those students who follow a Biology course, often has high attitude towards science. As argued by Gogolin & Swartz (1992) those who have high attitude towards science also have high attitude towards the value of science in the society, thus may have attitude towards biotechnology and its applications.



## Conclusions

This study provides the baseline data of Malaysia secondary students' level of knowledge and attitude towards biotechnology and its application. The findings are encouraging in that Malaysian students are knowledgeable in this relatively new field and its applications and demonstrate positive attitude towards certain applications. This field is dealt with at the secondary level and this study shows that the field should be dealt in more detail especially related to ethical issues of biotechnology applications in the Biology and General Science curriculum. Gaining a comprehensive view of the field namely being aware of its advantages and limitations will enable the students to make an informed decision on issues or policies relating to the advancement of biotechnology and its applications.

## References

- Bal, S., Samanci, N.K., & Bozkurt, O. (2007). University students' knowledge and attitude about genetic engineering. *Eurasia Journal of Mathematics, Science & Technology Education*, 3 (2), 119-126.
- Cavanagh, H., Hood, J., & Wilkinson, J. (2005). Riverina high school students' views of biotechnology. *Electronic Journal of Biotechnology*, 8 (2), 121-127.
- Chen, S. Y., & Raffan, J. (1999). Biotechnology student's knowledge and attitudes in the UK and Taiwan. *Journal of Biological Education*, 34 (1), 17-23.
- Dawson, V. (2007). An exploration of high school (12-17 year old) students' understandings and attitudes towards biotechnology processes. *Research in Science Education*, 37, 59-73.
- Dawson, V., & Schibeci, R. (2003a). Western Australian school students' understanding of biotechnology. *International Journal of Science Education*, 25 (1), 57-69.
- Dawson, V., & Schibeci, R. (2003b). Western Australian high school students' attitudes towards biotechnology processes. *Journal of Biological Education*, 38 (1), 1-6.
- Dawson, V. & Soames, C. (2006). The effect of biotechnology education on Australian high school students' understandings and attitudes about biotechnology processes. *Research in Science & Technological Education*, 24 (2), 183-198.
- Erdogan, M., Ozel, M., Usak, M., & Prokop, P. (2009). Development and validation of an instrument to measure university students' biotechnology attitude. *Journal of Science Education & Technology*, 18, 255-264.
- Firdaus-Raih, M., Sahidan, S., Abdul Munir, M., Nik Marzuki, S., Wan, K.L., Fauzi, D., Shahrul Hisham, Z.A., Zulkeflie, Z., Tan, C.S., Ahmad Sofiman, O., Sharr Azni, H., Mohd Yusof, R.S., & Rahmah, M. (2005). A nationwide biotechnology outreach and awareness program for Malaysian high schools. *Electronic Journal of Biotechnology*, 8 (1), 9-15.
- Gogolin, L., & Swartz, F. 1992. A quantitative and qualitative inquiry into the attitudes toward science of non science college students. *Journal of Research in Science Teaching*, 29 (5), 487-504.
- 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.
- Hansen, E. & Nascimento, L.A. (2003). Attitudes of Brazilian undergraduate students towards genetic engineering and genetically engineered products. *Eubios Journal of Asian and International Bioethics*, 13, 137-139.
- Hill, R., Stanisstreet, M., Boyes, E., & O'Sullivan, H. (1998). Reactions to a new technology: student's ideas about genetically engineered foodstuffs. *Research in Science & Technological Education*, 16 (2), 203-216.
- Kamaldeen, S., & Powell, D. A. (2000). *Public Perceptions of biotechnology*. Food Safety Network Technical Report #17. Canada: Department of Plant Agriculture, University of Guelph.
- Kitto, S. L., Griffiths, L. G., & Pesek, J. D. (2003). A long-term study of knowledge, risk, and ethics for students enrolled in an introductory biotechnology course. *Journal of Animal Science*, 81, 1348-1353.
- Klop, T., & Severiens, S. (2007). An exploration of attitudes towards modern biotechnology: a study among Dutch secondary school students find. *International Journal of Science Education*, 29 (5), 663-679.
- Lamanauskas, V., & Makarskaite-Petkeviciene, R. (2008). Lithuanian university students's knowledge of biotechnology and their attitudes to the taught subject. *Eurasia Journal of Mathematics, Science & Technology Education*, 4 (3), 269-277.
- Latifah, A., Jamaluddin, M. J., Abd. Rahim, M. N., Mohamad, O., & Nor Muhammad, M. (2006). Uncovering factors influencing Malaysian public attitude towards modern biotechnology. *Asia Pacific Journal of Molecular Biology and Biotechnology*, 14 (2), 33-39.
- Latifah, A., Jamaluddin, M. J., Abd. Rahim, M.N., Mohamad, O., & Nor Muhammad, M. (2007). Minireview: Public acceptance of modern biotechnology. *Asia Pacific Journal of Molecular Biology and Biotechnology*, 15 (2), 39-51.
- Lock, R. (1994). What do 14 to 16-year-olds know and think about biotechnology? *Nutrition & Food Science*, 3, 29-32.
- Lock, R., & Miles, C. (1993). Biotechnology and genetic engineering: students' knowledge and attitudes. *Journal of Biological Education*, 27 (4), 267-272.



- Lock, R., Miles, C., & Hughes, S. (1995). The influence of teaching on knowledge and attitudes in biotechnology and genetic engineering contexts: implications for teaching controversial issues and the public understanding of science. *School Science Review*, 76, 47-59.
- Malaysia (2006). *The Ninth Malaysia Plan 2006-2010*. Retrieved 3/08/2006, from [http://www.parlimen.gov.my/news/eng-ucapan\\_rmk9.pdf](http://www.parlimen.gov.my/news/eng-ucapan_rmk9.pdf)
- Massarani, L., & Moreira, I. de C. (2005). Attitudes towards genetics: a case study among Brazilian high school students. *Public Understanding of Science*, 14, 201-212.
- Ministry of Education Malaysia (2005a). *Integrated Curriculum for Secondary Schools: Curriculum Specifications, Science Form 4*. Kuala Lumpur: Ministry of Education Malaysia.
- Ministry of Education Malaysia (2005b). *Integrated Curriculum for Secondary Schools: Curriculum Specifications, Biology Form 4*. Kuala Lumpur: Ministry of Education Malaysia.
- Murat, O., Erdogan, M, Usak, M., & Prokop, P. (2009). High school students' knowledge and attitudes regarding biotechnology applications. *Educational Sciences: Theory & Practice*, 9 (1), 321-328.
- Nor Arizah, M. (2008). *Understanding and attitude of agricultural teachers towards the use of biotechnology in agriculture*. (Unpublished Thesis of Master Science Technical and Vocational Education). Universiti Putra Malaysia.
- Nur Aziera, S., Nur Riza, M. S., & Latifah, A. (2009). Model Development of Students Attitude towards Genetically Modified Food. *Sains Malaysiana*, 38 (2), 241-247.
- Nunally, J. C., & Berstein, I. H. (1994) *Psychometric theory*: Third edition (New York, McGraw Hill).
- Ozden, M., Usak, M., Prokop, P., Turkoglu, A., & Bahar, M. (2008). Student teachers' knowledge of and attitudes toward chemical hormone usage in biotechnology. *African Journal of Biotechnology*, 7 (21), 3892-3899.
- Prokop, P., Leskova, A., Kubiato, M., & Diran, C. (2007). Slovakian students' knowledge of and attitude toward biotechnology. *International Journal of Science Education*, 29 (7), 895-907.
- Saez, M. J., Nino, A. G., & Carretero, A. (2008). Matching society values: students' views of biotechnology. *International Journal of Science Education*, 30 (2), 167-183.
- University of Illinois at Urbana Champaign and International Service for the Acquisition of Agri-Biotech Applications. (2003). *Southeast Asians positive towards agri-biotech, exhibit high trust in university scientists and research institutes*. Retrieved 3/08/2006, from <http://www.isaaa.org/kc/Publications/pdfs/briefs/Brief3-2.pdf>.
- Usak, M., Erdogan, M, Prokop, P., & Ozel, M. (2009). High school and university students' knowledge and attitude regarding biotechnology. *Biochemistry and Molecular Biology Education*, 37 (2), 123-130.

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