# Slovakian students' knowledge of and attitudes toward biotechnology

Prokop, Pavol; Lešková, Andrea; Kubiatko, Milan; Diran, Carla


# Slovakian students' knowledge of and attitudes toward biotechnology

| | |
|---|---|
| Journal: | *International Journal of Science Education* |
| Manuscript ID: | TSED-2006-0089.R2 |
| Manuscript Type: | Research Paper |
| Keywords: | university, biotechnology education |
| Keywords (user): | attitudes, biotechnology, Slovakia |
| | |

## Introduction

The importance of science and technology education continues to increase its impact on peoples' everyday life (Lappan, 2000). Public perception of some controversial technologies indicates their association with technological risk (Fischoff, Slovic, & Lichtenstein, 1978). Biotechnology includes genetic modification that can be briefly defined as follows: 'Genetic modification concerns the transportation of genetic material from a living organism to another. These living organisms can be animals, plants or micro-organisms. In food production, the use of genetic technology could enable the transfer of desirable characteristics from one living thing to another, leading to disease resistance in plants, etc.' (Saba & Vassalo, 2002, p. 14). Biotechnology can be viewed as a typical example of high perception of risk (Slovic, 1987). DNA technologies were perceived to be very similar to hazards such as nuclear energy, radioactive waste, electromagnetic fields, and other technologies that use rays or chemical substances (Savadori et al., 2004). Although several studies deny the possibility of serious health hazards from the use of genetically modified (GM) foods (Jones, Clarke-Hill, Hillier & Shears, 2000; Lopez & Carrau, 2002), GM foods and crops claim to offer a range of benefits to a variety of beneficiaries, including higher productivity and lower pesticide costs for consumers; less environmental pollution from pesticides and herbicides, and new crop varieties to ameliorate hunger in developing countries (Welser, 1991).

Even though the public perception of GM products is the centre of controversy (Busch, 1991; Aerni 2002), the majority of experts judge that the benefits outweigh possible risks-if indeed there is any risk at all. Therefore, the role of science curriculum is to prepare students to be citizens with basic knowledge about genetic engineering.

Research into people's understanding of and attitude toward biotechnology showed that women are generally less accepting of genetically modified products than men (Mangusson & Hursti, 2002; Moerbeek & Casimir, 2005). Age and educational differences are also presumed to play an important role, although findings are very often contradictory (Baker & Burnhum, 2002; Dawson & Schibeci, 2004; Hamstra & Smink, 1996). Other important factors are differences in policy and GMO legislation among countries. For example, while GM crops in the European Union have not been commercially applied yet (Moerbeek & Casimir, 2005), the USA is the home of an estimated 63 % of global GM crops (James, 2003). This results in relatively more favourable attitudes of US consumers toward GM products in comparison with people from the UK (Moon & Balasubramanian, 2004).

Attitudes and knowledge toward biotechnology in school age students have been relatively less investigated in comparison with adult consumers. This is, however, a crucial stage of research in this area because this may reveal insufficiency of science curricula or school textbooks that are an important source of information on this topic (Martínez-Gracia, Gil-Quílez, & Osada, 2003). Briefly, approximately 20-50 % of the 15 – 19 year old students from the UK, Australia, and Taiwan have little understanding of biotechnology (Chen & Raffan, 1999; Dawson & Schibeci, 2003; Gunter, Kinderlerer, & Beyleveld, 1998; Lock & Miles, 1993). For example, 47 % of Lock and Miles's 16 year-old students failed to provide any example of biotechnology. A similar proportion of students (52 %) could not give an example of genetic engineering. About one-third of Taiwanese and UK students aged 16 – 18 could not define genetic engineering even about half of them were studying A level biology (Chen & Raffan, 1999). Comparable results have been currently reported from large sample (1116 students) of students surveyed in the Australia. About 20 – 30 % of students could not provide an example of genetic engineering, biotechnology, cloning or genetically modified foods (Dawson & Schibeci, 2003).

To date, no study was focused on the investigation of students' knowledge of and attitude toward GMO in Slovakia. In addition, Slovakia is a relatively conservative country where distribution of GM foods is banned by law. Thus, Slovak people are not constrained by everyday decisions to buy or not to buy GM foods labelled as "*This products is produced from genetically modified organisms*" (Pew Initiative on Food and Biotechnology, 2003). However, media that seem to be an important source of students' knowledge of biotechnology (Dimopoulos & Koulaidis, 2003; Gunter et al., 1998) often reports discussions about genetic engineering and biotechnology is a significant part of biology courses taught at Slovak universities. Therefore, Slovakia is currently in a somewhat interesting situation which can be changed totally after potential policy changes which will be less averse toward the use of GM products.

**The link between knowledge and attitudes toward biotechnology**

Allport (1935, p. 820) defined attitude as 'mental and neural state of readiness to respond, organised through experience, exerting a directive and/or dynamic influence on behaviour'. Many psychologist (Bagozzi & Burnkrant, 1979; Eagly & Chaigen, 1993) have proposed that attitudes have three components. The cognitive component refers to knowledge about the objects, the beliefs. The affective component includes feeling about object and its assessment is performed using psychological indices (heart rate). The behavioural component pertains to the ways people act toward the object.

Overall, it has been established that attitudes tend to be consistent and stable with time. Nonetheless, despite this stability, they are open to some change and development, although deeply held attitudes are highly internalised and are resistant to change (Reid, 2006).

A significant relationship between knowledge and attitudes has been found in several studies (DiEnno & Hilton, 2005; Tikka, Kuitunen, & Tynys, 2000; Weaver, 2002). It is generally appreciated that links between knowledge and attitudes exist. However, there are conflicting findings on whether an increasing understanding of biotechnology results in a change of students' attitudes about the use of biotechnology (Dawson & Schibeci, 2004). For example, Lock, Miles and Hughes (1995) found that after teaching about biotechnology, knowledge of 16 year old students significantly increased and their attitudes toward biotechnology were more positive. Chen and Raffan (1999) found that students studying A-level biology had more positive attitudes toward biotechnology that those not studying biology. Dawson and Schibeci (2004) also found that greater awareness of biotechnology resulted in more positive attitudes toward them. Although these data seem to be convincing, it should be noted that it is unclear what attitudes toward biotechnology had biology students *before* they attended to study biology (Dawson & Schibeci, 2004). In another research, Dawson and Taylor (1999) examined the effect of a 10 week transplantation course that introduced students to issues associated with transplantation and bioethical principles. Using both a pretest/posttest and a control group, they failed to find any significant differences between groups. Hill, Stanisstreet, Boyes, and O'Sullivan (1998) compared differences in attitudes and knowledge among 16 – 19 year old students with and without 'A' level biology. They found that students with 'A' level biology students had more knowledge about genetic engineering than those without biology and tended to more likely affirm statements about possible advantages of genetically modified foodstuffs. However, these authors conclude that these differences in students' attitudes about genetic engineering were not concerned in general, because some questions did not show differences in distribution of students' responses. In sum, there are few works that examined differences in attitudes toward biotechnology between more and less aware students empirically and very limited number of works that followed link between knowledge

and attitude experimentally. In addition, none of them have been conducted in Slovakia where students' attitudes toward biotechnology remain to be studied.

**Purpose**

Slovakian university students who have been studying to become primary and secondary teachers toward biotechnology were the subjects of this research. This paper explores the following questions: What is the extent of Slovak university students' knowledge of and attitudes toward biotechnology? Is there any relationship between students' knowledge of and their attitudes toward biotechnology? Are there any gender differences in knowledge of and attitudes toward biotechnology?

**Methods**

The study was conducted between October and December 2005. A total of 378 students (302 females, 72 males and four failed to provide some of their personal data) attending three different universities in Slovakia participated in the study. Because our research was conducted in educational faculties where strong female-bias in Slovakia historically exists, it was impossible to adjust female to male ratio more accurately. The age of students ranged from 18 to 25 (mean age was 20.7, SD = 1.68); only one student was 33 years old. Students have been studying to become primary or secondary school teachers. They study various disciplines while a significant part of them (217 of 378) enrolled in biology courses at various levels. First year students (103 out of 195) just started to study university biology, so they were experienced mostly in general biology course which include DNA replication, mutation, proteosynthesis, but no topics are directly related to biotechnology. In contrast, secondary pre-service teachers (114 out of 183) were experienced with genetics which includes genetic engineering in general. Although they did not study biotechnology explicitly, they can be

expected to be better informed about biotechnology compared to students who do not study any biology. The remaining 159 students enrolled mostly in humanities disciplines, and two failed to provide this information. Because the sample contained more and less students potentially aware about biotechnology, it allows us to compare more (enrolling biology course) and less (students enrolling humanities) educated students in terms of their attitude and knowledge of biotechnology.

*Instrument*

A 17 Likert-type Biotechnology Attitude Questionnaire (BAQ) items and 16 Likert-type Biotechnology Knowledge Questionnaire (BKQ) was used to examine students' knowledge and attitudes toward biotechnologies. Items were scored from 1 (strongly disagree) to 5 (strongly agree). As for statements representing a negative attitude, the score was reversed. Items of each research tool were modified following several studies focusing similar topic (namely, Arvanitoyannis and Krystallis, 2005; Lock and Miles, 1993; Olsher and Dreyfus, 1999; Priest, Bonfadelli and Rusanen, 2003; Subrahmanyan and Cheng, 2000; Wie, Strohbehn and Hsu, 1998).

The translation of the questionnaire from English to Slovak proceeds as follows: A bilingual speaker translated the English questionnaire into Slovak. A second bilingual speaker who was also expert in this field translated the English version independently from the first one. Then the two bilingual speakers consensually resolved the few resulting discrepancies between the original English questionnaire and translated Slovak version.

The validity of the translated and adapted version of the questionnaire was established through review by three experts in the field of genetics and biology education. All were asked if the items in each dimension were relevant to the goal of the questionnaire. Revisions were

based on their comments and suggestions. The full version of the questionnaire is available from the authors upon request.

*Reliability of the questionnaire*

Both BKQ (biotechnology knowledge questionnaire) and BAQ (biotechnology attitude questionnaire) showed appropriate reliability (Cronbach's alpha = 0.69 and 0.76, respectively). To examine relationship between BKQ and BAQ, split - half reliability and correlation calculation between these two research tools, was applied. Guttman's split – half reliability coefficient (0.68) and correlation between BKQ and BAQ was high (0.56) which suggests significant relationship between knowledge and attitude toward biotechnology. In addition, Cronbach's alpha calculated for BKQ and BAQ together also shows high internal consistency between items (α = 0.82). A graphical presentation of the relationship between knowledge and attitudes toward biotechnologies is shown in Figure 1.

Insert Figure 1 somewhere here

Attitude items comprise from three dimensions; "Public awareness of genetically engineered products" (4 items, α = 0.46), "Control of genetic engineering" (8 items, α = 0.75) and "Shopping of genetically engineered products" (5 items, α = 0.72). The Cronbach's alpha of the first dimension is relatively lower, and some caution must be made when interpreting these data.

*Analysis of students' knowledge of biotechnology*

Of the 16 biotechnology knowledge items only five were answered correctly by more than 50 % of participants (Table 1). Note that true items are marked 'T' and false items are marked

'F' in the table and were scored in the reverse order in further statistical comparisons (see below). The same is valid for Table 2. The remaining 11 items were correct for 14 – 49 % of students.

In general, the majority of students know that biotechnologies are associated with changes of DNA that can result in productivity increase and organisms' resistance against diseases (Table 1).

*Insert Table 1 somewhere here*

Items with least frequent scores are shown in Table 2. About one third of students think that GM organisms contain dangerous chemicals or do not know that genetic modification can increase nutritional quality and/or taste of products (Table 2). Surprisingly, two-thirds of students think, or do not know, if GM food can destroy human genes. A similar proportion of students believes that GM organisms are always bigger than normal. Concrete substances used in genetic modifications such as somatotropin were virtually unknown.

*Insert Table 2 somewhere here*

In order to examine what factors influence students' knowledge of biotechnology, analysis of covariance (ANCOVA) with gender and enrolment in biology courses (factors), age (covariate) and BKQ score (dependent variable) was used. A homogeneity-of-slopes GLM analysis did not reveal significant interaction between factors (gender or enrolment in biology courses) and age (covariate) which suggests that their age-related differences showed similar trends among boys and girls and among more or less educated students. The effect sizes analysis revealed medium power statistical test (Cohen's *d* for gender differences and for

enrolling biology course = 0.38 and 0.53, respectively) which suggest medium, but still satisfactory power of the test. Males have statistically significantly better knowledge of biotechnology than females (ANCOVA, $F_{1,366} = 10.6$, $p < 0.001$). Moreover, the students who graduated from biology courses scored statistically significantly better than those that do not (ANCOVA, $F_{1,366} = 23.9$, $p < 0.001$). Thus, both gender and biology course enrol significantly affect students' knowledge of biotechnology, although an interaction between these factors was only marginally significant ($F_{1,366} = 3.5$, $p = 0.06$). Detailed inspection of marginally significant interaction between gender and biology course showed that males have better knowledge only within a group that graduated from a biology course (Tukey HSD post-hoc test, $p < 0.001$). No gender differences in group of students that did not graduate from biology courses were found ($p > 0.76$).

*Analysis of students' attitude toward biotechnology*

Multivariate analysis of covariance (MANCOVA) was used to examine students' attitudes toward biotechnology (N = 378 students entered analysis). Because biotechnology knowledge among students greatly varied with respect to gender and biology course graduation, the score from the BKQ was used as a covariate. Age was defined as a second covariate in order to control for potential differences caused by age. Homogeneity-of-slopes GLM analysis did not reveal any significant effects of covariates on factors which indicate that their effects across subgroups was similar. Results indicate that males have a more positive attitude toward biotechnology than females, regardless of whether they were enrolled in a biology course (MANCOVA, $F_{3,364} = 3.3$, $p = 0.021$, see Fig. 2). The effect of knowledge was supported by calculation of Pearson correlation coefficients between BKQ and each dimension of BAQ score. We found that correlation coefficients ranged from 0.42 - 0.55, all were positive and significant at least at 0.01 level. This means that better knowledge of biotechnology resulted

in more positive attitudes toward biotechnology. Because of the significant effect of BKQ on BAQ score in all univariate tests presented below was found, we do not refer to it in further text.

*Insert Figure 2 somewhere here*

*Students' attitudes toward public awareness of genetically engineered products*

To determine whether there was a statistically significant effect of gender, enrolment in biology course, knowledge, or age, a univariate ANCOVA was used. None of these factors statistically influenced students' awareness toward GM products. Analysis of means per dimension (3.4 for females and 3.5 for males) suggest that attitudes were rather more neutral than positive. Almost all (93 %) of students want to know more about GM products and, consequently, only 3 % of all students agreed that the public is sufficiently informed about risks associated with genetically engineered foods. About half of the students (49 %) imply that the food industry takes necessary actions to provide safe genetically engineered foods. Only 16 % of students thought that current governmental regulations are sufficient to protect the public from risks associated with genetically engineered foods.

*Students' attitudes toward control of genetic engineering*

A univariate ANCOVA showed that females were statistically significantly more negative responses toward genetic engineering than did males ($F_{1,366} = 7.27$, $p = 0.007$). About 50 % of students are opposed to transfer of genetic material between animals and plants and similar proportion (43 %) suggest that manipulations with DNA are unethical. The majority of students (79 %) imply that advantages for biotechnologies in future are uncertain. Little more than half of students were against altering genes in fruit to improve their taste (58 %) or to

make them stay fresh longer (54 %). A total of 39 % of students disagreed with production of genetically modified plants.

*Students' attitudes toward shopping of genetically modified products*

A univariate ANCOVA showed that males were more accepting of shopping for genetically modified products than females ($F_{1,366} = 9.4$, $p = 0.002$). Other effects remained not statistically significant. Mean scores of most items were lower than 3 which suggest that students' attitudes toward shopping of GM products are rather more neutral than positive. Slovakian students are generally not willing to buy GM food; only 13 % of students were willing to buy genetically modified food; 42 % of students propose that consumption of GM food is risky; and 21 % would like to consume genetically modified tomato. The majority of students (89 %) focused on universally labelling GM products.

## Discussion

Our results indicate that Slovakian university students have a poor knowledge of what biotechnology processes mean. Students who enrol a biology course have a significantly better knowledge of biotechnology and the level of knowledge positively correlates with attitudes. However, as a result, Slovakian students (especially females) show less positive attitudes toward biotechnology regardless of their knowledge about genetic engineering. In general, the most negative attitudes were found in items related to control of genetic engineering which probably resulted in reluctance against shopping of GM products. Both of these seem to be in close relationship with knowledge of biotechnology. About half of the students thought that genetic modification is painful for animals and another 41 % thought that consumption of GM foods can destroy human genes. A high proportion of students who

incorrectly perceived the presence of dangerous chemicals in GM organisms (over half of participants) clearly documents poor knowledge, probably resulting in negative attitudes within these two dimensions.

These results are in strong contrast with those reported from the USA, where more familiar attitudes toward GM products had been found (Wie et al., 1998). However, other research reports from the European Union are more similar those found in our study, perhaps due to the more conservative policy of the European Union toward biotechnologies (Herrick, 2005).

Few effects of educational level on attitudes toward biotechnology corroborate with Dawson and Schibeci's (2004) finding from Australia and Chen and Raffan's (1999) report from UK and Taiwan. They found that pupils studying biology were more knowledgeable than those that were not studying biology. A similar trend was found by Hill et al. (1998) in 16 – 19 year old students from UK. Considering the significant correlation between attitudes and knowledge found in our study, higher level of knowledge about biotechnology may result in more positive attitudes (Chen & Raffan, 1999; Lock et al., 1995). However, students studying biology expressed similar neutral/negative attitudes than those who did not study biology, despite the fact that their scores from the biotechnology knowledge questionnaire were higher. Because of similar findings that were also reported by Dawson and Schibeci (2004), we suggest that lack of experiences with GM products in Slovakia could have a greater impact on students' attitudes rather than the level of knowledge of biotechnology.

Females' lower acceptance of biotechnology supports recent evidence that females have different views on science (Jones et al., 2000, Miller, Blessing, & Schwartz, 2006), technology and technological innovations (Cockburn & Ormrod, 1995). Gender differences

can be explained by the 'gender paradox' hypothesis (Moerbeek & Casimir, 2005) which proposes that females have more tentative attitudes towards new products than males because they buy food for children. Similar explanation for gender differences have been proposed by Hill et al. (1998). Less knowledge about biotechnology identified in females might be an additional co-factor of the gender differences in this study. However, some caution about comparison of males/females is needed given the large disparity in numbers.

Slovakia is one of the youngest members of the European Union (since 2005). Following its current policy, legalization of genetically engineered products in the near future can be expected. Thus, the public needs to be aware of this subject. The current Slovak science curriculum with respect to the presentation of genetic engineering should be therefore re-evaluated, and students' scientific literacy in this area must be greatly improved. We suggest that more biotechnology information sources, such as *Biotechnology Online* (www.biotechnology.gov.au) in Australia (Dawson & Schibeci, 2004) may help teaching about genetic engineering to be more effective. Science teachers' views of genetic engineering should not be neglected but further investigation in this topic is needed.

**Acknowledgement**

We would like to thank Professor David Treagust and two anonymous referees for their helpful comments on earlier draft of the manuscript.

**References**

Aerni, P. (2002). Stakeholder attitudes toward the risks and benefits of agricultural biotechnology in developing countries: a comparison between Mexico and the Philippines. *Risk Analysis*, *22*(6), 1123–1137.

Allport, G. W. (1935). Attitudes. In C. M. Murchison (Ed.), *Handbook of social psychology* (pp. 798 – 844). London, OUP.

Arvanitoyannis, I. S., & Krystallis, A. (2005). Consumers' beliefs, attitudes and intentions towards genetically modified foods, based on the 'perceived safety vs. benefits' perspective. *International Journal of Food Science and Technology*, *40*(4), 343–360

Bagozzi, R. P., & Burnkrant, R. E. (1979). Attitude organisation and the attitude-behaviour relationship. *Journal of Personality and Social Psychology*, *37*, 913–929.

Baker, G. A., & Burnhum, T. A. (2002). The market for genetically modified foods: consumer characteristics and policy implications. *International Food and Agribusiness Management Review, 4*, 351–360.

Busch L. (1991). Biotechnology: consumer concerns about risks and values. *Food Technology, 45*(4): 96, 98, 100–101.

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.

Cockburn, C., & Ormrod, S. (1995). *Gender and Technology in the Making*. Sage Publications, London.

Dawson, W., & Schibeci, R. (2003). Western Australian school students' understanding of biotechnology. *International Journal of Science Education, 25*(1), 57–69.

Dawson, W., & Schibeci, R. (2004). Western Australian high school students' attitudes toward biotechnology processes. *Journal of Biological Education*, *38*(1), 7–12.

Dawson, W., & Taylor, P. C. (1999). Teaching bioethics in science: Does it make a difference? *Australian Science Teachers' Journal*, 45, 59–64.

DiEnno, C. M., & Hilton, S. C. (2005). High school students' knowledge, attitudes, and levels of enjoyment of an environmental education unit on nonnative plants. *Journal of Environmental Education* 37, 13–25.

Dimopoulos, K., & Koulaidis, V. (2003). Science and technology education for citizenship: the potential role of the press. *Science Education*, *87*(2), 241–256.

Eagly, A. H., & Chaiken, S. (1993). *The psychology of attitudes*. Fort Worth, TX: Harcourt Brace Jovanovich.

Fischoff, B., Slovic, P., & Lichtenstein, S. (1978). How safe is safe enough? A psychometric study of attitudes towards technological risks and benefits. *Policy Sciences*, 9, 127–152.

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.

Hallman, W. K. (1996). Public perceptions of biotechnology: another look. BIO/TECHNOLOGY, *14*, 35–38.

Hamstra, A. M., & Smink, C. (1996). Consumer and biotechnology in the Netherlands. *British Food Journal*, *98*, 34–38.

Herrick, C. B. (2005). 'Cultures of GM': discourses of risk and labelling of GMOs in the UK and EU. *Area, 37*(3), 286–294.

Hill, R., Stanisstreet, M., Boyes, E., & O'Sullivan, H. (1998). 'Reactions to the new technology: students' ideas about genetically engineered foodstuffs'. *Research in Science & Technological Education*, *16*(2), 203–16.

James, C. (2003). Executive summary: global status of commercialized transgenic crops 2003 *Report of the International Service for the Acquisition of Agri-Biotech Applications* (http://www.isaaa.org) Accessed 2 October 2003

Jones, P., Clarke-Hill, P., Hillier, D., & Shears, P. (2000). Food retailers' response to GM controversy within the UK. *British Food Journal, 102*, 441–448.

Jones, M. G., Howe, A. & Rua, M. J. (2000). Gender differences in students' experiences, interests, and attitudes toward science and scientists. *Science Education*, *84*(2), 180–192.

Lappan, G. (2000). A vision of learning to teach for the 21st century. *School Science and Mathematics 100*, 319–325.

Lock, R., & Miles, C. (1993). Biotechnology and genetic engineering: students' knowledge and attitudes. *Journal of Biological Education, 27*(4), 267–273.

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.

Lopez, R. C., & Carrau, J. G. (2002). The GMO regulation in the EU and the commercial conflict with the U.S. Paper presented in the Xth EAAE Congress. *Exploring diversity in the European Agri-Food system*. 28-31 August, Zaragoza.

Mangusson, M. K., & Hursti, U. K. (2002). Consumer attitudes towards genetically modified foods. *Appetite*, 39, 9–24.

Martíinez-Gracia, M. V., Gil-Quílez, J., & Osada, M. J. (2003). Genetic engineering: a matter that requires further refinement in Spanish secondary school textbooks. *International Journal of Science Education, 25*(9), 1147–1168.

Miller, P. H., Blessing, J. S. & Schwartz, S. (2006). Gender differences in high-school students' views about science *International Journal of Science Education*, *28*(4), 363–381.

Moerbeek, H., & Casimir, G. (2005). Gender differences in consumers' acceptance of genetically modified foods. *International Journal of Consumer Studies, 29*(4), 308–318.

Moon, W., & Balasubramanian, S. K. (2004). Public attitudes toward biotechnology: the mediating role of risk perceptions on the impact of trust, awareness, and outrage. *Review of Agricultural Economics, 26*(2), 186–208.

Olsher, G., & Dreyfus, A. (1999). The 'ostension-teaching' approach as a means to develop junior-high student attitudes towards biotechnologies. *Journal of Biological Education*, *34*(1), 25–31.

Pew Initiative on Food and Biotechnology (2003) *U.S. vs. EU: An Examination of the Trade Issues Surrounding Genetically Modified Food.* Pew Initiative on Food and Biotechnology,

Priest, S. H., Bonfadelli, H., & Rusanen, M. (2003). The "trust gap" hypothesis: predicting support for biotechnology across national cultures as a function of trust in actors. *Risk Analysis, 23*(4), 751–766.

Reid, N. (2006). Thoughts on attitude measurement. *Research in Science & Technological Education*, *24*(1), 3–27.

Richmond. [WWW document]. URL http://pewagbiotech.org/resources/issuebriefs/ europe.pdf.

Saba, A., & Vassalo, M. (2002). Consumer attitudes towards the use of gene technology in tomato production. *Food Quality and Preference, 13*(1), 13–21.

Savadori, L., Savio, S., Nicotra, E., Rumiati, R., Finucane, M., & Slovic, P. (2004). Expert and public perception of risk from biotechnology. *Risk Analysis*, *24*(5), 1289–1299.

Slovic, P. 1987. Perception of risk. *Science, 236*(4799), 280–285.

Subrahmanyan, S., & Cheng, P. S. (2000). Perceptions and attitudes of Singaporeans toward genetically modified foods. *Journal of Consumer Affairs*, *34*(2), 269–290.

Tikka, P. M., Kuitunen, M. T., & Tynys, S. M. (2000). Effects of educational background on students' attitudes, aktivity levels, and knowledge concerning the environment. *Journal of Environmental Education, 31*(3), 12–19.

Weaver, A. A. (2002). Determinants of environmental attitudes. *International Journal of Sociology, 32*(1), 77–108.

Welser, J. R. (1991). An industrial perspective on biotechnology issues. *Food Technology*, *45*(4), 102, 104, 107, 109.

Wie, S. H., Strohbehn, C. H., & Hsu, C. H. C. (1998). Iowa dietitians' attitides toward and knowledge of genetically engineered and irradiated foods. *Journal of the American Dietetic Association, 98*(11), 1331–1333.

Figure 1. A correlation between the knowledge and attitudes toward biotechnology found in Slovakian students (Pearson $r = 0.57$, y = 3.095+0.897x, $p < 0.001$, N = 378).

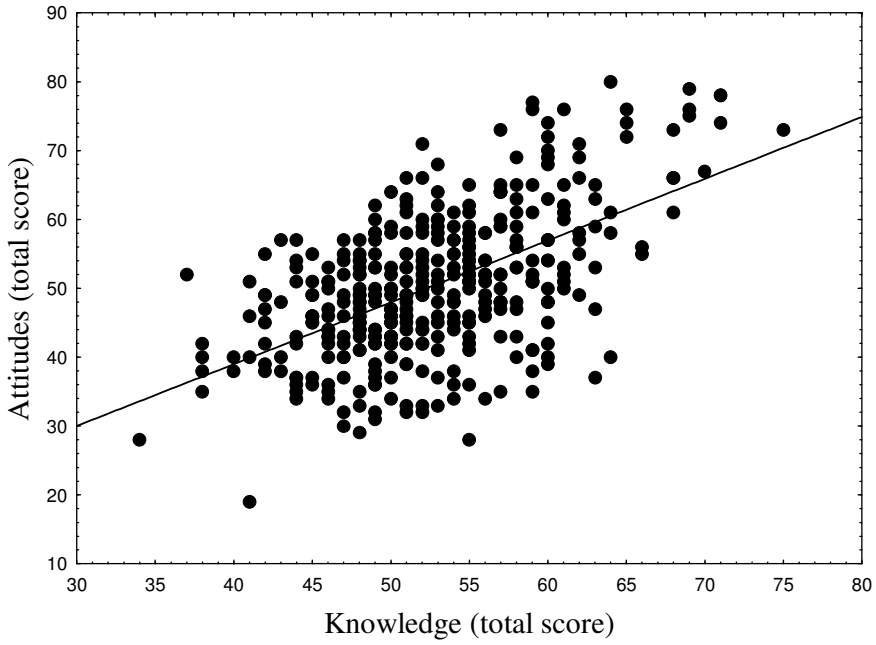

Figure 2. Differences between females (grey bars) and males (white bars) in attitudes toward biotechnology. Asterisks (**) denote statistically significant difference ($p < 0.01$).

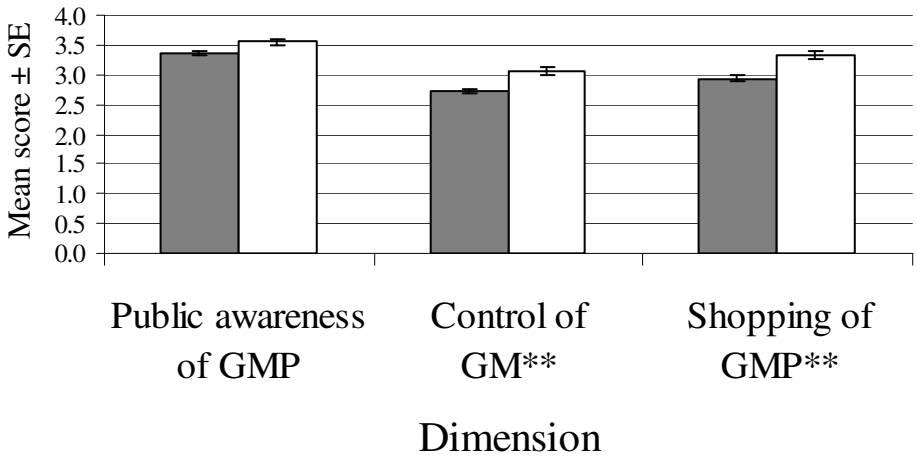

Table 1. Students' knowledge of biotechnology (N=378) .

| Items with most frequent correct responses | % Responded correctly | % Disagree | % Don't know |
|---|---|---|---|
| Practical application of GM plants may increase productivity and resistance of plants against diseases. (T) | 77 | 14 | 9 |
| Manipulation with DNA changes genes of GM organisms. (T) | 77 | 9 | 14 |
| Application of GM methods on animals can increase animal resistance against diseases. (T) | 65 | 15 | 20 |
| GM organisms are used in medicine (e.g. insulin production with GM microorganisms). (T) | 65 | 8 | 27 |
| Genetical modification is painful for animals. (F)• | 51 | 12 | 37 |

• Negatively worded item; reverse scoring procedure used.

Items with least frequent correct responses are shown.

Table 2. Students' knowledge of biotechnology (N = 378).

| Items with least frequent correct responses | % Responded correctly | % Disagree | % Don't know |
|---|---|---|---|
| GM organisms contain many dangerous chemicals. (F)• | 49 | 35 | 16 |
| Genetical modification to plants can increase nutritional quality and flavour of fruits and develops traits to withstand shipping process. (T) | 48 | 35 | 17 |
| Foods with increasing nutritional value and vitamins can be created through genetic modification. (T) | 48 | 27 | 25 |
| Microbes should be genetically engineered to make them more efficient at decomposing human sewage. (T) | 43 | 16 | 41 |
| Consumption of GM food can destroy human genes. (F)• | 38 | 41 | 21 |
| GM crops are sterile. (F)• | 38 | 21 | 41 |
| GM organisms are always bigger than normal. (F)• | 37 | 33 | 30 |
| It is possible to transfer genetic material between dissimilar organisms, such as animals and plants, because DNA is chemically identical. (T) | 33 | 41 | 26 |
| GM modification of poultry results in greater | 32 | 18 | 50 |

| | | | |
|---|---|---|---|
| proportion of lean. (T) | | | |
| Porcine somatotropin is a hormone active in hogs that directs dietary energy away from fat disposition toward production of lean muscle. (T) | 22 | 15 | 63 |
| Recombinant bovine somatotropin is an animal drug that increases milk produced by dairy cows. (T) | 14 | 8 | 78 |

• Negatively worded item; reverse scoring procedure used.

Items with least frequent correct responses are shown.