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ASSESSMENT OF PRESERVICE TEACHERS' KNOWLEDGE AND ATTITUDES REGARDING BIOTECHNOLOGY: A CROSS-CULTURAL COMPARISON

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Abstract. *This study examines the level of knowledge of and attitudes toward biotechnology of preservice teachers from Lebanon, Lithuania, Slovakia and Turkey. Data were gathered from a total of 768 preservice teachers from these four countries. The Biotechnology Knowledge Questionnaire and the Biotechnology Attitude Questionnaire were used for data collection. Three-way MANOVA was conducted to analyze the cross-cultural data. The results revealed that preservice teachers' knowledge of biotechnology in all four samples was below average. The results also demonstrated that there were significant differences in attitude towards biotechnology among preservice teachers in the four countries. In addition, significant gender differences were observed between male and females. Implications for teaching and further research are discussed.*

Key words: *biotechnology, knowledge, attitude, cross-cultural.*

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Introduction

The exponential scientific and technical advance in the twentieth century has spurred the development of new technologies that have influenced society significantly. One of these new technologies that represent an evolving area of scientific and technological innovations is biotechnology (Sturgis, Cooper, & Fife-Schaw, 2005). Its applications have been widely observed in various areas, ranging from agriculture, food industry, medical industry, and molecular biology to protection of the environment and human health. On the other hand, the significant achievements in this field raise numerous questions regarding potential risks, ethical concerns, moral acceptability, and usefulness of products resulting from biotechnological methods (Bailey & Lappe´, 2002; Reiss & Straughan, 1996).

Biotechnology has the potential to revolutionize various aspects of our daily life with new tools and products that might be useful in the treatment of diseases, increasing the shelf life of fruits and vegetables, decomposing human sewage, and improving the taste of fruits. Additionally, biotechnological methods may help protect the environment by increasing food quality and safety, reducing toxic products in soil, and cleaning up oil spills and heavy metals in ecosystems. In light of these possible benefits, there have been many policy changes to support to the biotechnology field in many different countries (Chaturvedi, 2003), while at the same making sure that products of biotechnology are not used until their safety is assured.

Together with these policy changes and growing activities in biotechnological research, there are related activities that are transforming biotechnology into an industrial pursuit that is integrated into our everyday life issues resulting in focused attention on the technology itself and on public perception of biotechnology (Hosseini & Rezaei, 2010). Public perception of biotechnology is important since it affects individuals' behaviors. Gaskell, Bauer, Durant, and Allum (1999), for example, found worldwide perceptions about genetically modified foods adversely affected their sales. Since the 1990s, there have been a variety of efforts to determine public perception of biotechnology and to inform the public about biotechnology. Among these efforts, the Eurobarometer surveys that measured biotechnology attitudes of the European public at large stands out. However, public perception of biotechnology is multifaceted (Crne-Hladnik, Peklaj, Košmelj, Hladnik, & Javornik, 2009) and it can be directly influenced by several factors such as age, gender, level of education, cultural and social differences, and perceived potential benefits and risks (Pardo, Midden, & Miller, 2002; Prokop, Le ková, Kubiatko, & Diran, 2007; Simon, 2009).

There have been few studies in the past two decades examining the knowledge and attitudes of preservice teachers toward biotechnology. Prokop et al. (2007), for example, investigated preservice students' knowledge and attitudes in Slovakia toward biotechnology. The results of this study showed that students have poor knowledge about biotechnology and the most negative attitudes were found in items related to genetic engineering. Türkmen and Darçın (2007) examined the levels of knowledge of Turkish elementary and science student teachers in biotechnology issues. Their results showed that, despite the fact that prospective teachers were knowledgeable about biotechnology and its relation to human health and pharmacy, almost all of them had inadequate knowledge about agricultural biotechnology, environmental biotechnology, and food production. Bal, Keskin-Samanci, and Bozkurt (2007) found that Turkish university students did not have adequate knowledge about basic principles of genetic engineering. Their results also demonstrated that these student teachers were ambivalent about genetically modified animals while they seemed positive about genetically modified plants.

Despite the knowledge regarding genetic engineering, genetically modified foods, and genetic modification products and attitudes toward these modern biotechnologies is crucially important for the next generations, less research has focused on preservice teachers' knowledge and attitudes toward biotechnology. Since there are not many studies about knowledge and attitudes of preservice teachers and about how cultural contexts contributed to these knowledge and attitudes, it is important to investigate preservice teachers' knowledge of and attitudes toward biotechnologies. It is also important to note that the research conducted on knowledge and attitudes toward biotechnology has been from a single country perspective. Research on knowledge and attitudes needs international discussion because the increasing effect of biotechnology is occurring across the globe (Lü, 2009). Research findings obtained from international studies can enhance our knowledge about what practices about biotechnology education in different cultural contexts and curriculum implementation works best. Thus, a large community of educators and researchers may able to use the research findings to prepare students to make informed decisions related to biotechnology, as a mean to develop scientific literacy. To this end, this study aimed to investigate knowledge of and attitudes toward biotechnology of preservice teachers' regarding biotechnology in the context of different countries. The research questions that shape and guide the overall study are as follows:

1. What is the extent of preservice teachers' knowledge of biotechnology in the four countries?
2. What are preservice teachers' attitudes on various applications of biotechnology in the four countries?
3. Do preservice teachers' knowledge and attitudes of biotechnology differ according to country, gender and major (subject area)?

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Educational Contexts of Biotechnology in Science Education

In Lebanon, the importance of biotechnology education has been recognized as a key point. This was addressed in the Convention on Biological Diversity [CBD] (2003). It specifically emphasizes that "the need for education, which will increasingly have to address GMOs as biotechnology becomes more and more a part of our lives" [CDB, 2003, p. 13]. However, a review of research in science education in Lebanon showed that there was no published research in the area of biotechnology.

In Lithuania, the inclusion of biotechnology in the curricula is evidence of the importance of biotechnology education. For example, the General Education Curricula for Lithuanian Comprehensive School [GECLCS] (1997) recommends that students should be able to reasonably evaluate modern biotechnologies (cloning, use of genetically modified organisms, etc.) and to characterize the process of developing genetically modified food products and rationally discuss the qualities and possible dangers of these products. Moreover, the *GECLCS* provides recommendations about how can be developed students' understanding of biotechnologies.

In Slovakia, although biotechnology is one of the topics in the national science curriculum, this does not seem to be adequate to prepare students who are knowledgeable about biotechnology (Prokop et al., 2007). Particularly, the curriculum is mostly focused on classic Mendelian genetics and molecular genetics. In addition, there is lack of instructional sources.

In Turkey, biotechnology has become an important topic. In the past decade, increased attention has been paid to biotechnology education (Severcan, Ozan, & Haris, 2000). Recent science education reform efforts recommend that "all students should develop scientific and technological literacy" (Ministry of National Education [MoNE], 2005, p. 5). The focus of this new reform is to promote the development of scientifically and technologically literate citizens, who are capable of making science-based decisions when solving everyday problems and developing positive values and attitude toward science.

Regarding science education for biotechnology, all countries involved in the study demonstrate noticeable differences. For example, in Lebanon, biotechnology is treated as an essential there is a need to increase the awareness toward GMOs as biotechnology, but little is known more about instructional approaches to accomplish this goal. In Lithuanian, science education guidelines present general directions about how can be promoted all the students' understanding of biotechnologies. In Slovakia, however, little is presented in the curriculum about biotechnology and at the present time there is a lack of instructional materials. In Turkey, biotechnology is a current topic that the advancement of scientific literacy is seen as a key point of the curricula at all levels. As aforementioned, the selected countries present various curriculum implementation and unique characteristics in terms of biotechnology education.

Significance of the Study

Despite the previously published research on preservice teachers' views about biotechnology, there is no consensus on the foci of these research studies. Put another way, no common focus was observed among the studies conducted. Although biotechnology education has recently gained attention, much of the research studies related to biotechnology knowledge and attitudes are not particularly attractive to compare across the countries. Few studies have attempted to conduct a comparative study comparing knowledge and attitudes toward biotechnology in the context of different countries (e. g., Chen & Raffan, 1999; orgo, Ambrožič-Dolinšek, Usak, & Özel, 2011).

Additionally, there are also three reasons for conducting the present study. First, there is a scarcity of research about biotechnology education, especially with respect to preservice teachers. Although there have been numerous studies related to genetic engineering and biotechnology has been conducted with high secondary students (e.g., Chen & Raffan, 1999; Dawson, 2007; Dawson & Schibeci, 2003; Klop & Severiens, 2007; Özel, Erdoğan, Uşak, & Prokop, 2009; Usak, Erdogan, Prokop, & Ozel, 2009), there have been limited studies which investigate preservice teachers' knowledge and attitudes towards modern biotechnology thoroughly.

Second, today's preservice teachers will be practicing teachers in the near future who will face an array of issues and they will have to make decisions regarding biotechnologies. Therefore, understanding their knowledge and attitudes toward biotechnology in different countries can provide important information for policy makers involved in determining curricular goals and directions.

Third, one of the most general purposes of science education is to develop scientific literacy (Goodrum, Hackling, & Rennie, 2001). An investigation on preservice teachers' biotechnology knowledge and attitudes can help in conceptualizing how cultural differences affect the perceptions of biotechnology. Moreover, a study conducted with the participants from different countries will provide a wider view of this issue. In addition, the findings of the present study may reveal evidence which could influence the organisation of teacher education programmes and the instructions given by faculty members in these programmes. Such a study can also provide opportunities for educators and researchers from a given country to reflect the practices (Guo, 2007).

Methodology of Research

Participants

A total of 768 preservice teachers in four countries participated in this cross cultural study. Of the participants, 81 (42 female, 40 male) were from Lebanon, 287 (224 female, 63 male) were from Lithuania, 210 (165 female, 45 male) were from Slovakia, and 190 (105 female, 85 male) were from Turkey. Moreover, 422 participants were from science-related departments where they took biology and related classes and were grouped as majors. The other part of them (n= 346) were from humanities and social science departments and did not enroll in biology classes and were grouped as non-majors. As can be seen in Table 1, most of the participants were females, especially those from Lithuania, Slovakia, and Turkey.

Table 1. Demographics background of study participants.

	Lebanon	Lithuania	Slovakia	Turkey
Gender				
Female	41	224	165	105
Male	40	63	45	85
Age				
19 and below	37	81	103	11
20-21	38	153	77	83
22 and above	6	53	30	96
Grade				
Freshmen	--	118	149	2
Sophomore	72	73	--	63
Junior	9	69	46	36
Senior	--	27	15	89
Subject area				
Major*	81	137	90	144
Non-major**	--	150	120	76

** Biology and related science majors ** Humanities and social science majors*

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Table 2. Factor name, number of items, and reliability of each factor in BAQ (N=326).

Factor names	Number of the items	Reliability (α)
Factor 1. Consumption of GM products	4	0.80
Factor 2. GM in agro industry	5	0.66
Factor 3. Public awareness of GMO	3	0.56
Factor 4. Shopping of GM products	6	0.79
Factor 5. Ethics of genetic modifications	3	0.61
Factor 6. Ecological impact of genetic engineering	4	0.61
Factor 7. Use of genetic engineering in human medicine	3	0.62
Whole instrument	28	0.82

Instruments

This study is a quantitative study in accordance with the nature of such comparative studies. In order to investigate participants' knowledge and attitudes toward biotechnology, two research instruments were used for data collection: the Biotechnology Knowledge Questionnaire (BKQ), and the Biotechnology Attitude Questionnaire (BAQ).

Biotechnology knowledge questionnaire. BKQ was developed by Prokop et al. (2007) and was used to examine participants' knowledge of biotechnology. This instrument consisted of 16 items with a 5-point Likert-type scale (strongly agree, agree, I do not know, disagree and strongly disagree). The questionnaire items assess knowledge of the applications of biotechnology in different areas such as animal and plant reproduction. A detailed description of the questionnaire can be found in (Prokop et al., 2007).

Biotechnology attitude questionnaire. BAQ was used to measure attitudes toward biotechnology. This instrument consisted of 28 items with a five-point Likert-type scale (strongly agree, agree, I do not know, disagree and strongly disagree) and was developed and validated by Erdogan, Özel, Uşak, and Prokop (2009). A principal components factor analysis was conducted on the data from the Likert-type scale questions from this BAQ gathered from the participants. Table 2 presents factor names, number of items and reliability of each factor in the questionnaire. The reliability of the whole instrument was .82. The BAQ includes both positive and negative items and thus the scores of the negative items were reversed during coding. The total scores obtained from this questionnaire ranged from 28 (minimum) to 140 (maximum).

Table 3. 2X2X4 MANOVA results.

Effect	Pillai's Trace	Value	F	Hyp. df	Error df	Sig.	Partial η2
Gender	P.T.	0.098	9.998	8	740	0.000	0.098
Major	P.T.	0.046	4.465	8	740	0.000	0.046
Country	P.T.	0.281	9.571	24	2226	0.000	0.094
Gender X Major	P.T.	0.024	2.269	8	740	0.021	0.024
Gender X Country	P.T.	0.030	0.947	24	2226	0.536	0.010
Major X Country	P.T.	0.068	3.242	16	1482	0.000	0.034
Gender X Major X Country	P.T.	0.028	1.299	16	1482	0.189	0.014

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The English versions of the questionnaires were used for participants from Lebanon and Lithuania. A Slovakian language version of both questionnaires was administrated to Slovakian preservice teachers. For Turkish preservice teachers, only questions in the BKQ needed to be translated into Turkish. The BAQ had developed in Turkish by Erdogan et al. (2009) and this version used for this study. During the adaptation of the questionnaire in Slovakia and Turkey, questionnaires were independently translated by two researchers who were bilingual and had significant knowledge of biotechnology. These translated questionnaires were reviewed by a group of science educators to identify differences between the translations. Furthermore, the items were back translated and were found to match the original items.

Data Collection and Analysis

The data for this study were collected from four countries because these countries were not involved in Eurobarometer surveys and there is scarcity of research findings regarding pre-service teachers' knowledge and attitudes toward biotechnology in the literature. All the participants were invited to respond to both questionnaires in a single session during spring semester of 2007-2008 in their classrooms and were supervised by course instructors. A common SPSS file including five demographic items along with the Likert-type items was prepared and sent to the researchers in each country who entered data collected in their countries. Then, the four separate data sets were combined into one data set.

Data cleaning procedures such as outlier analysis and missing data analysis were performed. Six cases were observed to be potential univariate outliers and were excluded, which resulted in a sample of 762. For only BKQ, the "strongly agree" and "agree" options were recorded and labeled as "correct" while the "strongly disagree" and "disagree" were recorded and labeled as "incorrect". For calculating the total score of each student, 1 point was assigned to "correct" and 0 point was assigned to "incorrect" and "I do not know". In order to examine the effects of participants' gender, major, and country on knowledge and attitudes regarding biotechnology applications, a 2 x 2 x 4 MANOVA was performed (n=762). Subsequently, a series of independent t-tests were performed to investigate pair-wise differences. Gender, major, and country were assigned as independent variables while the total score of BKQ and the seven factors of BAQ were assigned as dependent variables.

Results of Research

MANOVA results are presented in Table 3. However, only Pillai's Trace results are reported in the table since the Box's M Test, which measures the equality of covariance matrixes (Tabachnick & Fidell, 2001) was violated [Box's M = 796.465, $p < 0.01$]. Descriptive statistics for each country across are summarized in Table 4. Similarly, mean scores of dependent variables obtained by each country participants are presented in Appendix. Since there were several dependent variables, Bonferroni correction was used in order to overcome type-1 error. There were 6 dependent variables. The alpha level of 0.05 was divided by the number of the dependent variables resulting in a new alpha level of 0.0083.

The multivariate main effect of country [Pillai's Trace = 0.281, $F(24, 2226) = 9.571$, $p<0.001$, Partial $\eta = 0.094$], gender [Pillai's Trace = 0.098, $F(8, 740) = 9.998$, $p<0.001$, Partial $\eta = 0.098$] and major [Pillai's Trace = 0.046, $F(8, 740) = 4.465$, $p<0.001$, Partial $\eta = 0.046$] on the combination of the dependent variables were found statistically significant. Similarly, tgn4(i)62(a)-2(t)-2(gn4(i)62(a)b-2(i)-2(ln-2(a)2(t)-2(i)-2(so-2(ln-2(a

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Table 4. Mean score of dependent variables by country.

Dependent variables	Maximum/ Minimum	Lebanon	Lithuania	Slovakia	Turkey
Biotechnology Knowledge	0 – 16	7.8	6.13	6.69	6.83
Attitudes toward:					
1. Consumption of GM products	4 – 20	11.69	9.28	10.78	8.83
2. GM in agro industry	5 – 25	19.43	17.38	16.92	19.20
3. Public awareness of GMO	3 – 15	8.5	8.70	8.31	8.72
4. Shopping for GM products	6 – 30	16.45	14.28	14.94	13.25
5. Ethics of genetic modifications	3 – 15	10.16	8.21	8.23	7.77
6. Ecological impact of genetic engineering	4– 20	11.16	10.10	11.44	9.24
7. Use of genetic engineering in human medicine	3 – 15	12.23	10.36	10.81	10.82

Biotechnology Knowledge

The composite score for BKQ out of a maximum score of 16 was 7.8 for Lebanese participants, 6.83 for Turkish participants, 6.70 for Slovakian participants, and 6.13 for Lithuanian participants. The effect of country on biotechnology knowledge of the participants was found significant [$F(3, 747) = 4.329$, $p<0.001$, partial $\eta^2 = 0.017$]. Subsequent post hoc comparisons with Scheffe's test revealed that Lebanese and Turkish participants' biotechnology knowledge scores were significantly higher than those of Slovakian and Lithuanian participants.

The main effects of gender [$F(1, 747) = 28.04$, $p<0.001$, partial $\eta^2= 0.036$], and major [$F(1, 747) = 31.45$, $p<0.001$, partial $\eta= 0.040$] on biotechnology knowledge were also found significant. Male participants' biotechnology knowledge scores were significantly higher than those of female participants in Lithuania, Slovakia and Turkey, but not in Lebanon. Furthermore, participants majoring in science and related majors had higher biotechnology scores than those who were studying other majors (humanities and social sciences). Since there were no participants from social sciences or humanities in the sample from Lebanon, Lebanese data on this variable were not included in this part of the analysis.

The interaction effect of country-major on biotechnology knowledge was also found significant [$F(2, 747) = 6.641$, $p<0.001$, partial $\eta^2= 0.017$]. Analysis of multiple comparison results for interaction effects revealed that the differences in biotechnology knowledge among the four groups of the participants were significant and only observed among the ones who took biology and biology related classes. Turkish ($M = 7.96$) and Lebanese ($M= 7.80$) participants who took biology related classes had significantly higher biotechnology knowledge scores than those who took similar classes in Slovakia ($M = 7.12$) and Lithuania ($M = 6.39$). No significant differences were observed among the participants who were from humanities or social science departments.

Attitudes toward Biotechnology

Attitudes toward consumption of GM products. Out of a maximum score of 20, the mean score obtained for this sub-scale (Attitudes toward Consumption of GM Products) was 11.69 for the Lebanese sample, 10.78 for the Slovakian sample, 9.28 for the Lithuanian sample and 8.83 for the Turkish sample.

The main effects of country [F (3, 747) = 16.29, p<.001, partial η= 0.061] and gender [F (1, 747) = 26.05, p<0.001, partial η= 0.034] on attitudes toward consumption of genetically modified products (GMPs) were found significant. Follow-up Scheffe tests were performed to examine the pair-wise comparisons among the countries. This follow-up analysis indicated that Lebanese participants' attitudes toward consumption of GMPs were significantly higher than those who are from the other three countries. Slovakian participants' attitudes were higher than those from Turkey and Lithuania. Furthermore, male participants' attitudes ($M_{Slovakia}$ = 11.87 and $M_{Lithuania}$ = 10.17) toward consumption of GMPs were significantly higher than female participants ($M_{Slovakia}$ = 9.69 and $M_{Lithuania}$ = 8.39) only in Slovakia and Lithuania. No significant differences were observed in the Lebanese and Turkish samples.

Approximately 58 % of Lebanese participants did not accept the practice of altering genes in fruits to improve their taste. However, 63.9% of Lithuanian participants, 63.2% of Turkish participants, and 54.5% of Slovakian participants accepted this practice. Whereas 60% of Lebanese participants were against altering the genes of fruits and vegetables to make them last longer, only 38.3% of Slovakian, 32.3% of Turkish, and 21.9% of Lithuanian participants were against this alteration. Furthermore, a high percentage of females (63.4% and 63.2%) and almost half the males (45.9% and 47.1%) accepted both practices.

Most Turkish (65.7%) and Lithuanian (66.7%) participants believed that consumption of genetically modified foods (GMFs) was risky. Additionally, more than half the female and male participants disagreed with the fact that consuming GMFs was risky and they (78% of female and 65% of male) indicated that they would give GMFs to children. Finally, 81% of Turkish participants, 75.6% of Slovakian participants, 74.2% of Lithuanian and 52.5% of Lebanese participants indicated that they would not give GMFs to children.

The interaction effect of country-major on participants' attitudes toward consumption of GMPs was significant, [F (2, 747) = 5.52, p<0.001, partial η= 0.015]. Analysis of the multiple comparisons for interaction effect revealed that differences in participants' attitudes toward consumption of GMPs among the four groups of the participants were significant for all the participants. Among the ones who took biology and related classes, Lebanese participants' attitudes (M=11.69) were significantly higher than Lithuanian (M=8.31) and Turkish (M=9.67) participants; Slovakian (M=10.32) and Turkish participants' attitudes were significantly higher than Lithuanian participants. On the other hand, among the participants who did not take any biology related classes, Turkish (M=7.89) participants' attitudes were significantly lower than their counterparts in Slovakia (M=10.0) and Lithuania (M=9.22).

Attitudes toward GM in agro industry. Out of a maximum score of 25, the total mean score obtained from this sub-scale (Attitudes toward GM in Agro Industry) was 19.43 for the Lebanese sample, 16.92 for the Slovakian sample, 17.38 for the Lithuanian sample and 19.20 for the Turkish sample. Only the main effect of country on participants' attitudes toward genetic modification in agro industry was found to be significant [F (3, 747) = 18.51, p<0.001, partial η= 0.069]. Post hoc analysis performed to examine the pair-wise comparisons among the countries with regard to attitudes toward GM in agro industry revealed that Lebanese and Turkish participants' attitudes were significantly higher than Slovakian and Lithuanian participants. Also, Lithuanian participants' attitudes were significantly higher than Slovakian participants. Nearly all of Lebanese (93.8%) and most of Turkish (84.8%) and Lithuanian (78.5%) participants supported the use of genetic engineering for therapy of genetically determined diseases. Approximately, 73 % of Lebanese, 68.5 % of Turkish and 53% of Lithuanian participants supported the use of biotechnology to modify the genetic structures of plants to make them more resistant to damage by insects, thereby reducing pesticide applications. Finally, more than 50% of Lebanese and Turkish participants showed significantly higher attitudes toward the use of plants in which genes increasing quality and productivity were inserted.

Attitudes toward public awareness of GMO. Out of a maximum score of 15, the total score obtained from this sub-scale (Attitudes toward Public Awareness of GMO) was 8.5 for the Lebanese sample, 8.32 for the Slovakian sample, 8.70 for the Lithuanian sample and 8.72 for the Turkish sample. Since the total scores of all samples were somewhat close, none of the main effects and interaction effects was found significant. This result suggests that none of the independent variables affected participants' attitudes toward the public awareness of genetically modified organism. Despite the fact that 66.9% of Turk-

significantly higher than Slovakian, Lithuanian and Turkish students. Significant gender differences were only observed among Slovakian and Lithuanian participants in favor of males. Male participants and Lebanese participants seemed to be more concerned with the ethical dimension of genetic modification. Participants' support for the transfer of genetic materials between plants and animals ranged between 41.3% and 63.9%. Lithuanian participants' support was significantly higher than other participants' as evidenced by the fact that approximately 60% of male and 44.2% of female participants supported the transfer of genetic materials.

Almost 64% of Lebanese participants believed that manipulating DNA was unethical. However, other students' acceptance of manipulation with DNA was high (55.2% for Turkish participants, 53.3% for Lithuanian participants and 51.9% for Slovakian participants). Additionally, 52.5% of female and 45.9% of male participants believed that manipulation of DNA is ethical. Whereas a high percentage of Lebanese participants (68.5%) agreed that humans did not have the right to intervene in DNA because it is against nature, only 39.4% of the Turkish sample, 31.5% of the Lithuanian sample and 25.3% of the Slovakian sample agreed that humans have this right. Finally, approximately 56.2% of female participants agreed that humans had rights to intervene in DNA.

Attitudes toward ecological impact of genetic engineering. Out of a maximum score of 20, the total score obtained from this sub-scale (Attitudes toward Ecological Impact of Genetic Engineering) was 11.16 for the Lebanese sample, 11.44 for the Slovakian sample, 10.10 for the Lithuanian sample and 9.24 for the Turkish sample. The main effect of country [F (3, 747) = 22.16, p<0.001, partial η= 0.082] and gender [F (1, 747) = 14.14, p<0.001, partial η= 0.019], and the interaction effect of country-major [F (2, 747) = 53.79, p<0.001, partial η= 0.020] on the attitudes toward ecological impact of genetic engineering were significant. Post hoc comparisons indicated that Lebanese and Slovakian participants' attitudes toward the ecological impact of genetic engineering were significantly higher than Turkish and Lithuanian participants.

Significant differences were observed between male (M = 10.62) and female (M = 9.58) participants for only the Lithuanian sample in favor of males. A multiple comparison for the significant interaction effect of country-major revealed significant differences in participants' attitudes toward the ecological impact of genetic engineering among the four groups of participants and was evident for those who took biology and biology related classes and the ones who did not take such classes. Of the participants who majored in science, Lebanese (M=11.16) and Slovakian (M=11.39) participants showed significantly higher attitudes than Turkish (M=9.72) and Lithuanian (M=9.24) ones. Of the participants who majored in humanities or social sciences Slovakian (M=11.00) and Lithuanian (M=10.38) participants' attitudes were higher than Turkish (M=8.68) participants.

Whereas approximately 60% of Turkish and Lithuanian (53.1%) participants accepted the alteration of the genes in plants to produce more oils for use in industry, only 30.1% of Lebanese and 29.2% of Slovakian participants accepted this practice. Compared to participants in other countries, most Turkish participants (73.1%), and 60.6% of the females and 59.3% of the males believed that genetic manipulations do not disturb ecological balance. About 58% of all participants (56.9% - 59.2%) disagreed that there was a threat of hybridization between genetically modified and normal plants which would endanger original genetic resources of wild plants. Finally, while 57.9% of Turkish and 48.4% of Lithuanian participants did not support a ban on the production and purchase of genetically engineered products, 45.5% of Slovakian participants were undecided and 43.8% of Lebanese participants supported such a ban. Moreover, only about 40% of females and males supported such ban.

Attitudes toward use of genetic engineering in human medicine. Out of a maximum score of 15, the total score obtained from this sub-scale (Attitudes toward Use of Genetic Engineering in Human Medicine) was 12.23 for Lebanese sample, 10.81 for the Slovakian sample, 10.36 for the Lithuanian sample and 10.82 for the Turkish sample. The main effect of country [F (3, 747) = 9.12, p<0.001, partial η= 0.035], gender [F (1, 747) = 16.69, p<0.001, partial η= 0.022] and major [F (1, 747) = 6.37, p<0.001, partial η= 0.008] on the attitudes toward use of genetic engineering in human medicine was significant. Lebanese participants' attitudes were significantly higher than Lithuanian, Slovakian and Turkish students. Furthermore, Turkish participants' attitudes were significantly higher than Lithuanian participants. Male participants' attitudes ($M_{Slovakia}$ = 11.43 and M_{Turkey} = 11.17) were significantly higher than females

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($M_{Slovakia}$ = 10.19 and M_{Turkey} = 10.46) for Slovakia and Turkey. For only the Turkish sample, there was a significant difference between the participants who took biology related courses (M = 11.28) and those who did not (M = 10.36). Lebanese (65%), Slovakian (48.4%) and Turkish (54.8%) participants said that they would use of genetically modified microbes (GMMs) for decomposing human sewage. Whereas 58.4% of males and 56.1% of science majors accepted to use of GMMs microbes, only 41% of females and 34.5% of those humanities and social science majors said that they would use GMMs. Nearly all of the Lebanese (93.8%) participants, 75.3% of Turkish participants, 67.2% of Lithuanian participants and almost half of the Slovakian participants (51.6%) supported the use of genetic engineering for non-food purposes such as production of human medicine. Moreover, 63.7% of females, 67.1% of males, 74.8% participants who took biology and related courses, and 59.1% of those who took humanities and social science courses supported the use of genetic engineering for such purposes. Finally, 86.3% of Lebanese, 63.6% of Lithuanian, 61.7% Slovakian and 57.4% of Turkish participants supported the production of insulin by making use of GMMs and a relatively high percentage of female (61.2%) and male (70.2%) participants and those who took biology, humanities, and social science courses (68.6% and 58.3%) supported the use of GMMS for producing insulin.

Discussion

Biotechnology Knowledge

Results showed significant differences among countries. Participants in Lebanon and Turkey appeared to be more informed about biotechnology in comparison with those in Slovakian and Lithuanian. However, the overall mean scores suggest that participants' knowledge of biotechnology was not satisfactory. These findings are consistent with those of Prokop et al. (2007) and Turkmen and Darçın (2007), who found that preservice teachers do not have satisfactory levels of biotechnology knowledge.

These results suggest that college participants and preservice teachers in the four countries are either experiencing inadequate curricula (Dawson, 2007) or deficient teaching practices. The results presented above suggest college participants and preservice participants in the four countries do not have sufficient knowledge. These finding have serious implications because previous research (e.g., Brossard & Nisbet, 2007; Nisbet, 2005) has shown that knowledge plays an important role in making informed decisions about science-related issues and those participants who are well informed about biotechnological issues are usually more supportive of biotechnology.

Findings of this study also revealed that there were significant differences in knowledge by gender. Male participants in Lithuania, Slovakia and Turkey showed significantly higher biotechnology knowledge scores than females. However, why do females seem more likely to be pessimistic about biotechnology applications? First, research has shown that females are not interested nor motivated to pursue studies associated with technology and technological innovations (Moerbeek & Casimir, 2005; Sjöberg, 2004). Second, biotechnology is often associated with reproductive technology, and so women are more likely to be directely affected by it (Simon, 2009). Finally, Sjöberg (2004) reported that technologies are seen as disturbing because of their perceived interference with nature and natural processes; a situation that tends to be perceived as risky and women usually rate risks as both more dangerous and more likely than men do.

Another important finding in this study with respect to biotechnology knowledge is that participants' major had a positive effect on biotechnology knowledge. Participants who were majoring in biology and related subjects in Lithuania, Slovakia and Turkey scored significantly higher than those majoring in non-science related subjects. These results are consistent with the findings of Prokop et al. (2007) and Türkmen and Darçın (2007).

Attitudes toward Biotechnology

The results revealed significant differences in attitude towards biotechnology among preservice teachers in the four countries. Lebanese participants approved of the consumption of genetically modified products (GMPs) whereas the approval levels of those in other countries were relatively low. Moreover, male participants' attitude scores in Slovakia and Lithuania toward consumption of GMPs were significantly higher than the attitude scores of female participants; a finding that is consistent with that of Prokop et al. (2007). Furthermore, results indicate that the majority of Lebanese participants disapproved of the practice of altering genes in fruits to improve their taste, while more than half of the participants in Lithuania, Slovakia, and Turkey accepted this practice. Similar findings were also reported in a study conducted by Pardo et al. (2002), which showed that 43% of European adults agreed that genetic modification of food should be encouraged.

Differences among the participants in the four countries regarding the consumption of GMPs may have resulted from different views in the countries. As claimed by Pardo et al. (2002), the different approaches used by the media in the countries may have had some effects on participants' attitudes. Different views may stem from different perceptions of level of risk associated with consuming genetically engineered products. Furthermore, being in contact with biotechnology products (Bailey & Lappe´, 2002) could be another reason for these differences.

Findings show that participants in Lebanon and Turkey had significantly higher favorable attitudes toward the use of genetic modification (GM) in agro industry than participants in Slovakia and Lithuania. The findings also suggest that most of the participants in the four countries supported the use of genetic engineering for therapy of genetically determined diseases. The positions of the participants in this study are similar with previous studies conducted with high school participants (Massarani & Moreira, 2005) and adults (Pardo et al., 2002; Gaskell, Allum, & Stares, 2003). The findings of these studies suggest that the majority of the participants supported the use of genetic engineering for therapy of genetically determined diseases.

Similarly, most of the participants approved of the practice of making plants more resistant to insects by using biotechnology thereby reducing pesticide applications. These findings are consistent with the findings of Lock, Miles and Hughes (1995) and Pardo et al. (2002) who reported that people accepted the use of genetic engineering techniques to alter plants but less so when it came to modifying animals; a practice that they found unnatural, dangerous and unethical.

Another noteworthy finding in this study is that most of the participants in this study indicated that they would not purchase or eat GMPs, with Lebanese participants being the most opposed to these practices. Likewise, more than 60 % of the participants did not find it acceptable to insert genes from human cells into the fertilized eggs of sheep. However, Turkish and Slovakian participants' attitudes were significantly more positive than the attitudes of Lithuanian participants regarding these matters. These differences could be due to differences in curriculum and to the distribution of genetically engineered products in each country. This interpretation is supported by the fact that female participants and those who majored in the humanities were especially unwilling to purchase and eat GMPs.

The main finding emerging from the results of this study is that many participants did not grasp the impact of biotechnological applications; a finding that coincides with previously reported research results (e.g., Turkmen & Darcin, 2007). One of the implications of these results is that science educators need to emphasize the advantages and disadvantages of biotechnology applications. Moreover, it might be advisable for educators to involve participants in discussing the benefits, burdens and risks associated with biotechnology. This is important in light of the findings of the study of Verdurme and Viaene (2003) who reported that Belgian consumers who identified environmental risks associated with biotechnology also identified benefit factors.

Findings related to attitudes toward the use of genetic engineering in human medicine suggested that participants would support and approve such applications when they understand their benefits; findings that echo those of Massarani and Moreira (2005) and Pardo et al. (2002). The majority of participants from all the countries believe that current governmental regulations are sufficient to protect the public from risks associated with genetically engineered foods (GEFs). Conversely, they suggested that the public has not been sufficiently informed about risks of consuming GEFs. This might have resulted from a combination of low level of awareness of biotechnology practices and distrust in governmental regulations and control of GEFs.

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Conclusions

The participants from all four distinct countries appeared to have limited biotechnology knowledge. In this sense, it is apparent that biology and biotechnology curricula in these countries need to be reformed in the light of real life situations and recent changes in the area of biotechnology and genetic engineering. Furthermore, appropriate instructional methods should be used in such a way to involve participants in analyzing everyday socio-scientific issues while considering the values and beliefs of all concerned. The lack of instructional materials with a focus on socio-scientific issues (Macer, Asada, Tsuzuki, Akiyama, & Macer, 1996) may have been one of the reasons for the participants' inadequate knowledge and negative attitudes toward biotechnology. Consequently, there is a need to include controversial issues such as biotechnology and genetic engineering in teacher preparation programs. Of equal importance is providing educators with appropriate resources, such as informational texts, interactive activities, practical activities, and internet resources to help them develop meaningful and effective lessons.

Surveying participants regarding controversial issues by using qualitative methods is necessary but not sufficient. An in-depth understanding of how individuals think about biotechnology and the beliefs and values that underlie this thinking requires the use of qualitative as well as quantitative research methodologies. Moreover, there is a need to widen the scope of research to investigate how all citizens in a country think about such an important and still controversial socio-scientific subject because all of these citizens have the responsibility to take decisions regard the production and use of these substances.

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Appendix. Descriptive statistics and t-test results for the respondents across gender and major

		Lebanon			Lithuania			Slovakia			Turkey		
		N	M	t	N	M	T	N	M	T	N	M	t
Biotechnology Knowledge													
Gender	Female	41	7.35		224	5.65		165	5.81		105	6.58	
	Male	40	8.25	-1.16	63	6.60	-2.60*	45	7.58	-4.37**	85	7.07	-1.58
Subject area	Major	81	7.80		137	6.39		90	7.12		144	7.96	
	Non-major	0	-	-	150	5.86	2.79**	120	6.27	2.74*	76	5.70	7.37**
Factor 1. Consumption of GM products													
Gender	Female	41	11.05		224	8.39		165	9.69		105	8.56	
	Male	40	12.33	-1.37	63	10.17	-3.71**	45	11.87	-3.94**	85	9.08	-.82
Subject area	Major	81	11.68		137	8.96		90	10.68		144	9.66	
	Non-major	0	-	-	150	9.60	-2.28*	120	10.88	.50	76	7.99	3.52**
Factor 2. GM in agro industry													
Gender	Female	41	19.30		224	17.50		165	16.37		105	18.87	
	Male	40	19.55	-.34	63	17.24	.60	45	17.47	-2.03*	85	19.53	-1.36
Subject area	Major	81	19.43		137	17.48		90	17.33		144	19.39	
	Non-major	0	-	-	150	17.27	.20	120	16.51	2.13*	76	19.01	1.08
Factor 3. Public awareness of GMO													
Gender	Female	41	8.45		224	8.70		165	8.30		105	8.66	
	Male	40	8.55	-.24	63	8.70	.01	45	8.33	-.03	85	8.78	-.49
Subject area	Major	81	8.50		137	8.62		90	8.38		144	8.58	
	Non-major	0	-	-	150	8.27	-1.14	120	8.24	.58	76	8.85	-98
Factor 4. Shopping of GM products													
Gender	Female	41	15.80		224	12.86		165	13.62		105	12.32	
	Male	40	17.10	-1.55	63	15.70	-5.02**	45	16.26	-4.29**	85	14.18	-2.26*
Subject area	Major	81	16.45		137	13.54		90	14.76		144	14.49	
	Non-major	0	-	-	150	15.03	-3.09**	120	15.11	.67	76	12.01	4.22**
Factor 5. Ethics of genetic modifications													
Gender	Female	41	9.90		224	7.45		165	7.40		105	7.62	
	Male	40	10.43	-.79	63	8.97	-3.85**	45	9.07	-4.01**	85	7.92	-.42
Subject area	Major	81	10.16		137	8.12		90	8.06		144	8.34	
	Non-major	0	-		150	8.29	-1.05	120	8.41	1.06	76	7.18	3.13**
Factor 6. Ecological impact of genetic engineering													
Gender	Female	41	10.80		224	9.58		165	11.00		105	9.00	
	Male	40	11.53	-1.21	63	10.62	-2.72**	45	11.88	-.96	85	9.48	-.99
Subject area	Major	81	11.16		137	9.51		90	11.44		144	9.72	
	Non-major	0	-	-	150	10.70	-3.56**	120	11.44	1.62	76	8.76	2.41*
Factor 7. Use of genetic engineering in human medicine													
Gender	Female	41	11.83		224	10.25		165	10.19		105	10.46	
	Male	40	12.63	-1.86	63	10.47	-.61	45	11.43	-3.60**	85	11.17	-2.55*
Subject area	Major	81	12.22		137	10.59		90	10.86		144	11.28	
	Non-major	0	-	-	150	10.12	1.35	120	10.76	1.55	76	10.36	7.37**

** Significant at 0.05 level*

*** Significant at 0.01 level*

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