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Lithuanian University Students' Knowledge of Biotechnology and Their Attitudes to the Taught Subject

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The impact of genetic engineering on peoples' everyday life has become present reality. In order to establish the level of the available schoolchildren and university students' knowledge of biotechnology, various investigations have been conducted. However, the current situation in Lithuania remains unclear. A total of 287 students - pre-service teachers from Lithuanian universities participated in the survey focused on attitudes to and knowledge of biotechnology. Our results confirmed the conclusions reached in other countries: students' knowledge of biotechnology is very miserable and attitudes frequently contradict one another. Research results clearly show the necessity for the increase and development of teacher training in the field of biotechnology and point to the ability to obtain and apply knowledge at international level in work practice. Research confirmed the opinion that the history and principles of developing biotechnologies as well as a legal and institutional system of using biotechnologies in Lithuania and the European Union needed to be more exhaustively introduced to all students.

Keywords: Science Education, Biotechnology, Attitudes, University Students.

INTRODUCTION

In recent times, the problems of science and technological education are given increased attention. One of these unique educational fields is knowledge of biotechnology and students' attitudes towards this subject[1]. It is supposed the impact of the latter area on people's everyday life is steadily growing (Lappan, 2000). Society accepts some technologies as controversial tools causing certain risks (Fischoff, Slovic, Lichtenstein, 1978). On the other hand, biotechnologies are deeper penetrating into public life wider using their potentialities. The Bulletin of the European Communities (2007) underlines that the sciences of animate nature and biotechnology are rapidly progressing fields making a direct impact on business and politicians in Europe. These two areas are getting more and more important and publicly acknowledged. Modern biotechnologies are also accepted as one of the major fields of the development of high technologies.

Modern biotechnology includes different types of technologies related to animate organisms or their products used in the food and medicine industry and helps with cultivating plants and animals, forming organisms for specific use and improving human health and local surrounding. However, biotechnology is an

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[1] http://stats.oecd.org/glossary/index.htm

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old and strongly developed branch of science. Since the ancient times, flora and fauna have been selectively bred whereas micro organisms have been used to make such products as bread, cheese, wine and beer. Some of the archaeologists' findings can be dated 5000 BC. Modern biotechnology based on recombinant DNA or hybridoma technology (technology for producing specific antibodies) is applied for manufacturing new food and formation products and assists in solving environmental problems. Therefore, biotechnology covers a few fields including agriculture, industry, environment and pharmacology (Biotechnologijos apžvalga, 2008).

The term 'biotechnology' was first used by the Hungarian engineer Karl Ereki in 1917. He described the process of breeding pigs applying the industrial method the basis of which was using sugar beets. The scientist referred to biotechnology as to the process of work when products were produced from material using animate organisms. The European scientists agree that biotechnology is a science that employs different fields of science to stimulate technological processes (biochemistry, microbiology, genetics and chemistry) supported by the structures of microbiological and mammalian cells (Biotechnologijos Lietuvoje, 2008).

Biotechnologies are present and future reality. It is worth emphasizing that due to genetically modified organisms (GMO), the world seems to be divided into two separate groups – the ones who support the idea of a further development of biotechnologies (for instance, such powerful international corporations and business establishments as MONSANTO, BASF etc.) and those who oppose this position (for instance, movement Gene Protection Initiative; the majority of the EU countries impose a limit on genetical modifications in order to change the use of the organisms). The foregoing idea is supported by undertaking as biotechnologies are definitively a profitable (relatively useful) area. The opposing side states that the impact of biotechnologies on nature still needs more investigation, for example, GMO impact on nature and human in general is not clear enough. Brazauskienė (2007) accepts there is no doubt that supporters' vigilance and responsibility are thrown into the shade by a strong interest and expected profit whereas the opponents rely on students' honesty, objective attitude and a deep feeling of obligation. Consequently, society's informativeness must be appropriate and objective. Some of the countries try to restrict the use of GMO. For instance, since 2 February 2006, Greece, Austria and Poland have been countries free from GMO. (http://gmolt.wordpress.com/zonos-be-gmo/). Even Romania, which is one of the most opened countries to genetically modified (GM) plants, pushes forward the idea of changing its position (http://gmolt.wordpress.com/2008/04/09/rumunija-permasto-savo-pozicija-del-genetiskai-modifikuotu-augalu/). The above mentioned facts only confirm the conclusion that GMO are not in demand in Europe.

Though Raney and Pingali (2007) approve biotechnologies and believe they are absolutely necessary in the modern world as 'genetically modified plants can help with overcoming poverty and famine, nevertheless, a new green revolution must consider and follow barely satisfied requirements'. The article argues that the present-day man must be well informed, inquisitive, concerned, responsible and critically thinking in order to properly apply the latest biotechnologies and do not cause any harm neither to him/herself nor to other people or the environment s/he lives in. To find out secondary school learners and university students' (Barman, 1980; Dawson, et. al. 2003) varying positions on biotechnology, a large number of research have been carried out in different foreign countries (Sterling, Halbrendt, Kitto, 1993; Macer, Azariah, Srinives, 2000; Prokop, Leškova, Kubiatko, Diran, 2007; Bal, Keskin Samancý, Bozkurt, 2007).

It should be stressed that when discussing the problems of biotechnology, Lithuanian general education is not out of question. For example, General Primary Education Programmes for Lithuanian Comprehensive School (2007) present the goal of science education and point out that to achieve it '…students take an interest in the development of sciences and technologies in Lithuania and abroad and are involved in acknowledging the priority trends towards the development of sciences and technologies at national level…' The supposed Development of Students' Abilities describes the 9th and 10th - formers abilities to 'reasonably evaluate modern biotechnologies (cloning, use of genetically modified organisms, biological fuel etc.); characterize the process of developing genetically modified food products and with reference to the examples given, rationally discuss the qualities and possible dangers of these products; on the basis of the patterns of using microorganisms in biotechnology, explain the importance of the variety of these organisms.' The new document puts emphasis on the attitude to critically evaluate the use of biotechnologies. The guidelines on science education of forms 5, 6, 7 and 8 also suggest how to develop students' understanding of biotechnologies. For example, the guidelines on education of forms 5 and 6 indicate that 'when examining the benefit of achievements in sciences for humankind, it is essential to remember defining the impact of accomplishments on the social and natural environment and to show how the new technologies frequently bring not only progress but also cause social and ecological problems'. Analogically, the same situation is reflected in the guidelines on sciences of forms 7 and 8. For instance, 'an evaluation of the impact of science and technologies

on human being, society and environment frequently reveals a contradictory situation'. It should be acknowledged that the prior General Programmes (1997, 2004) narrowly focused on learners' understanding of biotechnologies and their abilities to adopt personal attitudes (Lietuvos bendrojo lavinimo mokyklos...., 2007).

More than a year ago (2007-05-17), the conference 'Biotechnology in Lithuanian Universities' organized by the Commission of Biotechnology under Lithuanian Academy of Sciences and UAB Sicor Biotech was held in Lithuania. Although the representatives of Lithuanian universities discussed the situation of biotechnology in the establishments of higher education, the condition and future prospects of fundamental / applied research and possible collaboration between science and undertaking institutions, however, the questions of education were not considered. The issues of educating the young generation at university level almost were not examined. There is no doubt biotechnology is really the field of the future the significance and impact of which will gain more weight. Bumelis supposes that biotechnologies are very attractive fields of science, and therefore a student finds them as a completely new stage of gaining knowledge (Bumelis, 2004). Thus, to sum up, further in-depth research is necessary in order to convey an adequate knowledge of biotechnology and to form positive and right attitudes to biotechnology.

The object of research is the attitudes to and knowledge of biotechnology of the students studying pedagogical curricula in higher schools. The goal of research is to establish students' attitudes to biotechnology and the level of the available knowledge of biotechnology.

METHOD

General Characteristics of Research

Research was carried out in January-February, 2008. A total of 287 students (77.7% female (N=223) and 22. 3% male (N=64)) from two universities training pre-service teachers participated in the survey.

Table 1. Respondents' distribution considering the year of studies

Year of studies	N	%
First	118	41.1
Second	69	24.0
Third	73	25.4
Fourth	27	9.4
Total	287	100.0

The table shows that in the majority of cases, the first year students participated in the survey whereas the fourth year students were the least active. 137 (47.7%) respondents study biology, the rest of those (150 / 52.3%) have chosen the curricula of other profile including pedagogy of primary education, pre-school and primary school education, pedagogy of physical education and sport etc.

The students from Vilnius Pedagogical University study sciences and biology. Though no clear marking exists, the students of sciences are trained for work with 5th and 6th form children in basic school since the pre-service teachers of biology are prepared for work in the higher forms. However, the pre-service teachers of sciences have a broader view on sciences and its cohesion. It can be maintained that the studies of biology students are deeper while on the contrary the curricula of the students dealing with sciences are broader. The students studying social sciences counting educology (pedagogy of primary education) and psychology were also involved in research. The educologists study an integrated course on nature, geography and history along with didactics of world study while psychologists certainly examine human biology and zoopsychology. The respondents from the Department of Educology represented the University of Siauliai where the curricula of other subjects rather than natural sciences are implemented. Only a few of the modules such as 'a holistic conception of natural phenomena' reflect the field of sciences.

It is likely that the 1st year students of biology study the course on general biology which mainly does not approach the topics of biotechnology. It can also be stated that the students of the further courses have more knowledge of biotechnology. Therefore, it is essential to compare the attitudes of the latter two groups to biotechnology presuming that their statistical significance should be wide. The respondents aged from 18 to 29 (average age is 20.41 / SD = 1.45) took part in research.

Instruments and Statistical Analysis

An interval Likert scale (Prokop, Leškova, Kubiatko, Diran, 2007) made of 37 statements was applied to analyze the attitudes and a similar scale containing 16 statements was used to examine knowledge of biotechnology. Thus, the instrument of research was compiled from 53 statements. Each of those was evaluated from 1 (strongly disagree) to 5 (fully agree). Number 3 indicated a neutral position. The list of the statements is presented in the tables below. The statistical averages of each of the statements were calculated. The false/negatively worded items were scored in reverse order. To fix statistical deviations, the Student-t criterion for unrelated samples was chosen.

RESEARCH RESULTS

Respondents' Knowledge of Biotechnology

The following arrangement of the assessed students' evaluations was made (Table 2). The table displays evaluations considering each of the statements. The assessed respondents' answers preliminary confirm the hypothesis that students' knowledge of biotechnology is poor.

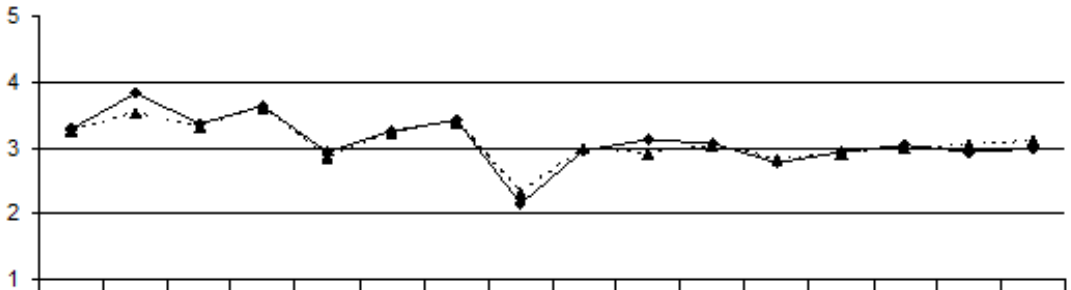
In order to improve the quality of food, extensive investigations into GM food products are conducted. For example, the increase of the quantity of vitamins A and E in food products can help with reducing the number of certain diseases. Experiments on raising the quality of proteins in vegetal products, decreasing the number of allergens in milk and grains etc. are conducted. The obtained findings reveal that the respondents mainly do not know the situation as the average of the answers to Statement 8 makes 2, 23 (the respondents principally disagree with the statement that foods with increased nutritional value and vitamins can be created through genetic modification). In terms of Statements 5, 9 and 16, the respondents had no position which shows a notable lack of knowledge about biotechnology. The respondents agreed on Statements 1, 2, 3, 4 and 7. Averages deviate from 3, 27 to 3, 67. It can be maintained that in the majority of cases, the respondents are not certain about their available information. Those having at least rudimentary knowledge certainly should accept the first four statements as in reality, practical application of GM plants may increase productivity and resistance of plants against diseases, GM organisms are used in medicine etc. The respondents in the main suffer from shortage of knowledge of whether genetical modification is painful for animals.

A comparison of knowledge of the respondents studying biology and other subjects was made (Table 2, Figure 1). The graphical chart clearly shows that none of the statements was fully supported or strongly objected by the surveyed participants.

The chart indicates that both the students of biology and those studying other subjects have no understanding of whether genetical modifications are painful for animals. Apart from Statement 2, the rest were almost equally answered by all respondents i.e. the parametrical Student-t criterion did not establish any statistically significant deviations between two groups of the respondents – the students of biology ant those studying other subjects. An interesting situation can be observed discussing Statement 2 which is Manipulation with DNA changes genes of GM organisms. It seems to be typical that in this case, statistically significant deviations between two groups of the respondents can be noticed. Knowledge of the students of biology about manipulations with DNA is slightly better than those of other respondents (t=2,765, df=285, p=0,006). A presumption that such situation can be determined by a deeper knowledge of the students of biology in the field of general biology is acceptable.

Table 2 presents the results considering each of the statements. A comparison of the results obtained in both groups of the respondents was drawn.

Although in respect of other statements (except Statement 2), knowledge of the students in both groups do not substantially differ, however, some points are worth paying attention. For example, Statement 12 focuses on transferring genetic material between dissimilar organisms. Nevertheless, information on the ability of microorganisms to transfer genetic material to other organisms and cause plant, animal and human diseases is introduced in the middle of the course on biology in the curriculum of secondary comprehensive school. It could be admitted that the students of the humanities and social sciences feel lack of such



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Biology	3,29	3,82	3,38	3,63	2,94	3,27	3,43	2,15	2,96	3,11	3,07	2,77	2,92	3,04	2,92	2,99
Non-Majors	3,25	3,53	3,32	3,61	2,84	3,22	3,39	2,31	3	2,9	3,05	2,81	2,91	3	3,03	3,09

***** Numbers from 1 to 16 in the Figure are the numbers of the statements shown in Table 2.

Figure 1. Comparison of the respondents' knowledge of biotechnology in both groups.

Table 2. Comparative characteristics of knowledge of biotechnology in both students' groups

Statements	Biology		Non-Majors	
	X	SD	X	SD
1. Practical application of GM plants may increase productivity and resistance of plants against diseases.	3.29	1.16	3.25	1.16
2. Manipulation with DNA changes genes of GM organisms.	3.82	0.84	3.53	0.93
3. Application of GM methods on animals can increase animal resistance against diseases.	3.38	1.07	3.32	1.01
4. GM organisms are used in medicine (e.g. insulin production with GM microorganisms).	3.63	1.00	3.61	0.83
5. Genetical modification is painful for animals.	2.94	1.05	2.84	0.86
6. GM organisms contain many dangerous chemicals.	3.27	1.04	3.22	1.07
7. Genetical modification to plants can increase nutritional quality and flavour of fruits and develops traits to withstand shipping process.	3.43	1.19	3.39	1.25
8. Foods with increasing nutritional value and vitamins can be created through genetic modification.	2.15	1.01	2.31	1.09
9. Microbes should be genetically engineered to make them more efficient at decomposing human sewage.	2.96	1.11	3.00	0.88
10. Consumption of GM food can destroy human genes.	3.11	1.12	2.90	1.13
11. GM organisms are always bigger than normal.	3.07	1.03	3.05	1.14
12. It is possible to transfer genetic material between dissimilar organisms, such as animals and plants, because DNA is chemically identical.	2.77	0.98	2.81	0.87
13. GM modification of poultry results in greater proportion of lean.	2.92	0.86	2.91	0.91
14. Porcine somatotropin is a hormone active in hogs that directs dietary energy away from fat disposition toward production of lean muscle.	3.04	0.74	3.00	0.65
15. GM crops are sterile.	2.92	0.92	3.03	0.94
16. Recombinant bovine somatotropin is an animal drug that increases milk produced by dairy cows.	2.99	0.85	3.09	0.77

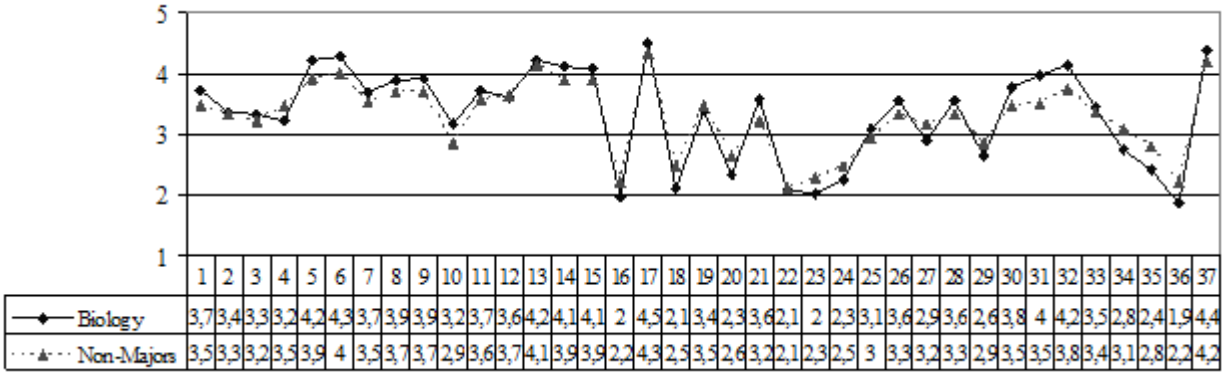


Figure 2. Comparison of the respondents' attitudes to biotechnology in both groups.

knowledge; however, the students of biology definitely should have before-mentioned information even though they do not attend a special course on biotechnology as the data of this kind is analyzed during the classical courses on genetics, microbiology etc. at university level. Statement 15 indicates a similar situation as the students of biology should know that the majority of modified plants are sterile i.e. cannot be reproduced and interbred. In fact, the respondents fail to know that somatotropin is not a drug but growth hormone that increases growing all textures and bones and has a strong impact on mobilization of sebum.

Thus, an assessment of the respondents' answers discloses that knowledge of biotechnology of the students in both groups does not largely differ.

Table 3. Comparative characteristics of attitudes to biotechnology in both students' groups

Statements	Biology		Non-Majors		t-statistics
	X	SD	X	SD	
1. I am opposed to transfer of genetic material between plants and animals.	3.72	1.14	3.47	1.06	
2. Manipulations with DNA are unethical.	3.35	1.15	3.34	1.08	
3. Men do not have rights to intervene to DNA, it is against nature.	3.33	1.26	3.23	1.19	
4. I agree with use of cloning for saving of endangered species.	3.22	1.38	3.47	1.30	
5. Use of genetic modification to change plants should be strictly regulated.	4.23	0.82	3.91	1.04	t=2.872, p=0.004
6. Use of genetic modification to change animals should be strictly regulated.	4.29	0.87	4.01	0.99	t=2.526, p=0.012
7. Altering the genes in fruit to improve their taste is not acceptable to me.	3.70	1.17	3.54	1.14	
8. I am against altering the genes of fruits and vegetables to make them stay fresh longer.	3.89	1.12	3.69	1.24	
9. Consumption of genetically modified food is risky.	3.93	0.96	3.70	0.96	
10. Use of GM microbes to decomposing human sewage is acceptable to me.	3.16	1.15	2.86	0.96	t=2.414, p=0.016
11. I support the use of genetic engineering for non food purposes such as production of human medicines.	3.73	1.11	3.59	1.20	
12. I agree with production of insuline with using genetically modified microbes.	3.60	1.04	3.65	0.89	
13. Nobody know what genetic engineering will bring in the future.	4.23	0.90	4.14	0.95	
14. I would not give GM food to children.	4.12	1.02	3.89	1.01	
15. I agree with the use of genetic engineering if it helps with therapy of genetically determined diseases.	4.07	0.92	3.89	0.87	
16. Genetically modified food does not influence human health.	1.96	0.94	2.23	1.01	t=-2.343, p=0.020
17. Universal labelling of genetically engineered foods should be required.	4.50	0.88	4.34	0.87	
18. I would eat genetically modified tomatoes.	2.12	1.03	2.46	1.09	t=-2.735, p=0.007
19. Genetically modified food contains dangerous chemicals.	3.38	0.99	3.47	0.90	
20. I think that genetically modified products taste better.	2.34	1.06	2.64	1.04	t=-2.396, p=0.017
21. During shopping I am interested whether the product is made from genetically modified stuff.	3.58	1.19	3.21	1.11	t=2.721, p=0.007
22. If I find that the product is made from genetically modified stuff, I will buy it.	2.09	1.01	2.12	0.89	
23. Inserting genes from human cells into the fertilized eggs of sheep is acceptable to me.	2.03	1.09	2.27	1.07	
24. I support changing the genes in cattle to make their meat more nutritious to eat.	2.26	1.13	2.47	1.09	
25. Using genetically engineered sheep to produce medicines for humans is not acceptable to me.	3.09	1.19	2.95	1.07	
26. I support the use of food biotechnology to modify plant' genetic structure to be more resistant to damage by insects, thereby reducing pesticide applications.	3.56	1.14	3.32	0.94	
27. Altering the genes of plants so that they will grow better in salty soils is acceptable to me.	2.89	1.08	3.16	0.99	t=-2.210, p=0.028
28. We should not alter the genes in plants to get them to make more oils useful in manufacturing.	3.56	1.11	3.33	0.92	
29. I agree with the use of plants in which genes increasing quality and productivity were inserted.	2.63	1.16	2.85	1.05	
30. Genetic manipulations disturb ecological relationships.	3.77	1.01	3.46	0.99	t=2.598, p=0.010
31. There is a threat of hybridization between genetically modified and normal plants which would endanger original genetic resources of wild plants.	3.97	0.85	3.50	0.95	t=4.402, p=0.000

Table 3. Continued

Statements	Biology		Non-Majors		t-statistics
	X	SD	X	SD	
32. Genetically modified plants can displace original plants in natural habitats.	4.15	0.95	3.76	0.95	t=3.490, p=0.001
33. I would support a ban on the production and purchase of genetically engineered products.	3.45	1.19	3.35	1.08	
34. I trust the food industry to take necessary actions to provide safe genetically engineered foods.	2.76	1.17	3.07	0.93	t=-2.528, p=0.012
35. I think current governmental regulations are sufficient to protect the public from risks associated with genetically engineered foods.	2.42	1.03	2.81	0.93	t=-3.364, p=0.001
36. Public is sufficiently informed about risks associated with genetically engineered foods.	1.87	0.98	2.23	0.94	t=-3.160, p=0.002
37. I want to know more about genetically engineered foods.	4.39	0.83	4.20	0.91	

Respondents' Attitudes to Biotechnology

The following distribution of the assessed respondents' evaluations is given below (Table 3, Figure 2). An assessment of the distribution shows that none of the statements is fully supported by the respondents. All surveyed participants mainly do not agree with Statements 16, 18, 20, 22, 23, 24 and 36 i.e. in terms of genetically modified food, the respondents' attitudes are negative. They think that such food does not taste better and would be tend not to buy if found it genetically modified. All respondents disagree on the statement that public is sufficiently informed about risks associated with genetically engineered foods. The students are inclined to agree on the first 15 statements except from Number 10 as they believe that manipulations with DNA are unethical and it still remains unclear what genetic engineering will bring in the future. The respondents should try to protect children from genetically modified food. They accept the idea that universal labelling of genetically engineered foods should be required. Without regard to the curriculum of studies, all surveyed participants would like to know more about genetically engineered foods.

The attitudes of the students of biology and those studying other subjects were individually compared (Table 3, Figure 2). A chart clearly indicates that none of the statements was fully supported or strongly objected by the surveyed participants.

Table 3 shows the results in view of each of the statements. The obtained results in both respondents' groups were compared.

The attitudes of the respondents in both groups principally agree. 14 of the 37 attitudes statistically differ. The statistical-t criterion for unrelated samples established deviations under the some statements when $p<0.05$ and $df=285$.

An evaluation of the use of genetic modification to change plants and animals shows that the students of biology are more demanding than those studying other subjects. However, both groups suppose that the situation should be strictly regulated. In terms of the use of genetically modified microbes to decompose human sewage, the respondents took a neutral position. Nevertheless, the students of biology rather than their colleagues dealing with other subjects are less biased in favour of the latter statement. Both sides believe that genetically modified food influence human health but in this case, the students of biology are more critical. They are also deeper interested during shopping whether the product is made from genetically modified stuff. The students of biology rather than the rest agree that genetic manipulations disturb ecological relationships and that there is a threat of hybridization between genetically modified and normal plants which can endanger original genetic resources of wild plants. Supposedly, similar differences can be influenced by a deeper knowledge in the field of the students of biology who disagree on the statement that public is sufficiently informed about risks associated with genetically engineered foods. In terms of the latter statement, other students support a more neutral position. Accordingly, the pre-service teachers of biology rather than other students are tending to think that the food industry fails to take necessary actions to provide safe genetically engineered foods.

DISCUSSION

The development of biotechnologies should definitely change society's position on this field of science. Due to insufficient and often inadequate information, the public has a wrong opinion about this area. In the context of society, the question of morality becomes a burning issue, especially discussing genetic engineering, cloning etc. It can be maintained that biotechnology as any of innovations in science is mainly neither a good nor a bad idea because everything depends on how achievements in this field of science are applied in practice. In this case, a crucial point is that

society should have an adequate knowledge in this area and form appropriate attitudes.

Different international investigations point to a poor knowledge of biotechnology. R. Lock and C. Miles (1993) questioned 188 students and found out that one third of the sample, and more males then females, did not know what biotechnology or genetic engineering was, and nearly half the sample could not give examples of either biotechnology or genetic engineering. A similar situation occurred in Taiwan and the United Kingdom between 17 – 18 years old respondents - in both countries 50 per cent of students were able to give examples of biotechnology and about 60 per cent were able to give examples of genetic engineering (Shao-Yen Chen, Raffan, 1999). On the other hand, the learners find knowledge of biotechnology interesting and significant if the field is properly introduced (Dori, Tal, Tsaushu, 2003). Some of research showed that the interest of students in biotechnology and genetic engineering develops at an age of about 16 (Todt, Gotz, 1998). At this stage, the learners are more interested in moral-ethical questions rather than in a real knowledge of biotechnology. Our investigation only confirmed the statement on the links between knowledge and attitudes – poor wrong knowledge has an appropriate impact on forming the wrong attitudes. The fact is approved by the previous research conducted in different countries (Jallinoja, Aro, 2000; Prokop, Leškova, Kubiatko, Diran, 2007).

The results of the passers-by questioned in the street should probably be similar to those received during student survey and introduced in this article. Literacy of the latter respondents on this issue should be insufficient. It is likely, that a phobic point of view on the use of biotechnologies should prevail: 'what will happen if …', 'no idea what will be created in the future', 'will they manage to control genetical processes' etc.

Similarly to students' research, two levels of understanding should probably become evident: one is formed only looking to the future i.e. biotechnologies used in food, medicine etc. have a direct impact on human life (for example, medicines, disease prevention … will receive a more favourable evaluation. How to understand a similar situation? Does it mean that of the two evils is chosen the lesser?); the second is an indirect one, for example, biotechnologies applied for run-off cleaning. Although the latter topic is also globally important, however, it is less intriguing. The same kinds of biotechnologies are not strictly evaluated. Despite the fact that it is a shortsighted attitude, such position exists. Lack of qualified scientific analysis and interpretation in the field of education forms a wrong attitude to the above mentioned problem.

The Post Soviet World faces another problem. Along with the process of creating and developing legal basis, numerous examples of ignoring laws exist (for instance, disorder in marking food products). Practice shows that people in Lithuania improperly examine the labels on the products. The expiration date of a product is the major part consumers are frequently focused on.

Biotechnologies are not properly introduced to society. The articles in the daily papers often include rumours as scientific periodicals are read by a small amount of readers. Nevertheless, research indicates that the larger part of the respondents would like to get more information on biotechnology.

Thus, what are the steps to be followed?

- Biotechnologies should be more exhaustively discussed in the final classes of secondary school. Communication between scientists and teachers is very important at this stage of education.
- Biotechnologies as a subject of studies could be examined not only in the curricula of natural but also in social sciences. For example, the module *A Holistic Conception of Natural and Social Phenomena* taught at the University of Siauliai is included in all curricula of studies as a general course which minimally covers and discusses the questions of biotechnologies.
- The methods of active teaching/learning could provoke discussions and help with developing critical thinking. A purposeful idea is arranging meetings between learners and experts working in the field of biotechnologies. Training students at modern level is impossible without the integration of educational institutions with research and scientific-production organizations. Close cooperation with research centres allows students to gain practical experience of work, to become acquainted with the latest scientific achievements, to participate in fulfilling real scientific and technical developments, to prepare term and degree works in actual research areas (Troshkova, Karabintseva, 2007).
- A valid point is an extensive use of TV, radio and the Internet disclosing information on the questions of biotechnologies to society.
- Knowledge improvement should not be the only purpose. A proper understanding of usefulness, risks and drawbacks occurring in this field of study is extremely important to the students of comprehensive schools and universities.

CONCLUSIONS

A conclusion of the carried out research reveals that:

- knowledge of biotechnology of the students studying pedagogical curricula at university level

is poor, contradictory and frequently unfairly treated;

- 9 of the 16 presented statements have not been validly answered by the students who made an attempt to give an answer only to 7 statements i.e. to agree or disagree on the statement given;
- no statistically significant deviations between the students of biology and those studying other subjects (not related to biology) have been established. It is supposed that the available information in the field is largely based on general education rather than on knowledge gained in university. However, knowledge of the students is rather limited. It is likely that the curricula of biology sharply focus on classical rather than on modern fields of biology.
- the surveyed participants have a position on the question dealing with biotechnology (position 3 - no opinion - was chosen to answer one fourth of the statements given) and agree that a part of those have a dramatic impact on the environment;
- all respondents acknowledge that society is not sufficiently informed about the risks related to genetically modified organisms and engineered food products. Food manufacturers, mass media and politicians must properly concentrate on these burning issues;
- certain deviations in the attitudes of biology students and of those studying other subjects can be noticed. The students of biology surely have more knowledge of biotechnology which determines their attitudes to the subject.

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