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University Students' Knowledge and Attitude about Genetic Engineering

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Genetic engineering and biotechnology made possible of gene transfer without discriminating microorganism, plant, animal or human. However, although these scientific techniques have benefits, they cause arguments because of their ethical and social impacts. The arguments about ethical ad social impacts of biotechnology made clear that not only getting basic knowledge about biotechnology and genetic engineering, also ethical and social issues must be thought in the schools, because the level of knowledge and the attitudes of new generation is very important for the society. So, in this study it is tried to determine the university students', level of knowledge about genetic engineering and their attitude towards genetic engineering applications. For determining the students' level of knowledge and attitude about genetic engineering, a questionnaire, which include 2 open ended questions and Likert type attitude scale with 12 statements, is given to students and wanted to answer. Answers of the open ended questions in the questionnaire are subjected to content analysis and students' level of knowledge about this field is tried to determine. The statements in attitude scale with 12 subject is grouped under 3 titles; and to evaluate the answers to the statements in attitude scale, percentage values and group differentiations are calculated by SPSS. The results have shown that students do not have sufficient knowledge about basic principles of genetic engineering and their attitudes towards the applications change according to species of organisms and the objective of the study.

Keywords: Biotechnology Education, Ethics Education, Genetics education, Teacher Education, Attitude

INTRODUCTION

Scientific literacy requires citizens interested in and understand the world around them, to be skeptical about scientific matters, to be able to identify questions and draw evidence-based conclusions, and make informed decisions about environment and their own health and well-being. So, school science curriculum has to prepare students for their future roles as citizens among technologies which will have a significant impact on their lives like genetic engineering and biotechnology (Dawson & Schibeci, 2003).

Genetic engineering and biotechnology with the techniques of solving limits of genetic material and making changes on the genetic material can make possible of gene transfer without discriminating microorganism, plant, animal or human. Beside these techniques benefits, it has some uncertainties and risks in some issues about;

- Genetic screening,
- Eugenics,
- The use and production of embryos and embryonic stem cells,

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- Culture and consumption of genetically modified (GM) corps,
- Environmental effects of GM corps,
- Biodiversity,
- Selective aborts

Because of these issues genetic engineering has become the subject of ethical discussions. Supporters of the biotechnological revolution suggest that biotechnology will be capable of relieving problems of human disease, hunger and pollution. Opponents fear this field represents "a form of annihilation every bit as deadly as nuclear holocaust" (Rifkin, 1999). These arguments in social dimension make clear not only getting basic knowledge about this topic also social effects of using knowledge and application methods must be determined. Indeed, it is important that students continue to be provided with appropriate science content, but it must be recognized that this knowledge alone may not be sufficient for students to make rational decisions (Harding & Hare, 2000). There is strong consensus among educators that training in the ethical and social consequences of science is necessary for the development of students into the science professionals and well-rounded citizens needed in the future (Booth & Garrett, 2004). An increase in the public understanding of biotechnology could be used to balance the extreme views that often have no basis in fact or logic (Edmondston, 2000). So, in last years the studies about the knowledge level and attitudes of society and especially the students', to the ethical topics in genetic engineering and application fields of biotechnology become important, because genetic engineering and biotechnology will effect their future lives in many fields.

For example with this aim in 1999 the social structure and education programs different English and Taiwanese students (Chen & Raffan, 1999), and in 2003 Australian students (Dawson & Schibeci, 2003) knowledge level and their attitudes towards the applications about biotechnology and genetic engineering are tried to determined; beside these, it is tried to determine the level of ethical topics in genetic lessons at the universities that give biological education.

In this field, if the studies are examined, Turkey is in the beginning of this way. However, fundamental genetic engineering and biotechnology subjects, besides having scientific knowledge they have applications fields in different fields, become subjects of ethnic, religious and cultural discussions and because of these reasons they must be determined in the developing countries like Turkey. With the providing data, young people who will decide about applications results of the social topics in the future have to be educated with learned and conscious. To provide social knowledge and consciousness; the teachers must be educated with sufficient and actual knowledge and ability of getting new developments.

OBJECTIVE

The purpose of this study was to determine students' knowledge and attitudes towards genetic engineering. The participants were juniour and seniour students from science education program (S.E. 3rd year and S.E. 4th year), seniour students from biology education program (B.E. 4th year) and seniour biology majors (B.D. 4th year) from the Faculty of Arts and Sciences.

MATERIAL AND METHOD

Material

In this study, for determining the students' level of knowledge and attitude about genetic engineering, a questionnaire, which include 2 open ended questions and 3 of Likert type of attitude scale with 12 statements, is given to students and students were wanted to answer. Firstly the scale was applied to 70 people group that has some features with study group. With the help of the data which is obtained from the application, it is decided that some statements are not appropriate for research. The indelicate statements are quieted from the scale and the statements which need to be changed are corrected. As a result of this correction, 2 open ended questions and the attitude scale with 12 statements is taken into the questionnaire.

For reliability of the questionnaire, specialist's opinions are consulted for the statements in the attitude scale. The reliability coefficient of measurement results is calculated as $\alpha = .81$. In answering open-ended questions, to prevent students affecting from the statements in the attitude scale, the attitude scale is scattered after open ended questions are answered and collected.

Method

Answers of the open ended questions in the questionnaire are subjected to content analysis and the students' level of knowledge about this field is tried to determine. The student's answers to the questions are put in groups and their frequency (f) and percentage (%) values are calculated. The definition of "genetic engineering" term in the Dictionary of Biological Terms which is a publication of Atatürk Culture, Language and History High Institution, is used as a right definition reference (Karol, Suludere & Ayvalı, 1998).

The statements in attitude scale with 12 subject is grouped under these titles; "The statements about the studies of genetic engineering", "The statements about the studies of genetic engineering with animals", "The

statements about the studies of genetic engineering with plants", "The statements about the studies of genetic engineering with microorganisms". To evaluate the answers to statements in attitude scale, percentage values and group differentiations (One Way ANOVA and Seheffe) are calculated by SPSS.

Study Group

In this study, the study group consisted of the students' of Gazi University Gazi Faculty of Education, Science Education (S.E.) Department, Biology Education Department (B.E.) and Faculty of Arts and Science, Biology Department (B.D) students. The dissociation of research students according to Faculty and Departments are showed in Table 1;

The students, who participate in the study, have chosen according to four groups to make comparison, according to their Faculty and Departments:

1. Students who did not take "Genetic" course (S.E. 3rd year students),
2. Students who took "Genetic" course (S.E. 4th year students),
3. Students who took "Genetic" course (B.E. 4th year students),
4. Students who took "Genetic" course and elective "Genetic Engineering" course (B.D. 4.th year students).

Table 1. The dissociation of research students according to faculty and departments

Faculty/Department/Class	N
Gazi Education/ S.E./ 3	47
Gazi Education/ S.E./ 4	36
Gazi Education/ B.E/ 4	43
Faculty of Arts and Science/ B.D/ 4	25
Total	**151**

RESULTS AND DISCUSSION

The Results about Students' Answers to the Open Ended Questions

While evaluating open ended questions the reference definition is used and the answers of students "use of genetic material in various applications" and "studies about genetic material for human benefit" are accepted as right answers.

As showing in Table 2, 29.3 % of S.E. 3rd year students, 33% of S.E. 4th year students, 28 % of B.E. 4th year students can make right definitions about meaning of genetic engineering. It is conspicuous that the teacher candidate's B.E. and S.E. answer rate to the question is very low. The other findings about other researches are showed that most of the students can not make right definition of genetic engineering (Wever, 1996; Chen & Raffan, 1999).

However, when Table 2 is examined, it is seen that 84 % of B.D. students can make right definition of genetic engineering. The reason of the high rate of B.D. students' answers according to the S.E. and B.E. students can be interpreted as these B.D. students take optional genetic engineering lesson beside genetic lesson.

Students' answers to questions are shown according to the groups of majors and years in Table 3.

When Table 3 is examined, all students in the research give example about the mediatic topics like copying, the diagnosis and treatment methods of hereditary diseases, forensic case in high rates. Moreover, it is seen that while the number of courses about the subject increases, the specific examples rate, like obtaining productive and resistant plant species, gene maps, obtaining drug, vitamin etc. products from bacteria with gene transfer increase too. For example, while S.E. 3rd year students and S.E. 4th year students can give the example of obtaining drug, vitamin etc. from bacteria, 9.3% of B.E. 4th year students and 20% of B.D. 4th year students can give this example. While most of (84%) of B.D. students who take genetic engineering lesson beside genetic course can make right definition about genetic engineering and at the same time they can give many little known examples about this field. When the answers of students who did not take Genetic Engineering are examined; it is seen that they give examples especially about the subjects take part in media.

There has got similar findings at the study with English and Taiwanese students about determining their knowledge and attitude about genetic engineering (Chen & Raffan, 1999). According to this study; English students with their examples of definition of genetic engineering and application of genetic engineering are found more successful than Taiwanese students. The basic reasons for this are listed like; English students can find more opportunity to discuss ethical subjects in their lessons, they can reach the literatures easily, Science man- teacher and also student cooperation in England is supported by many biotechnology center. Another study with 222 students in America, 7.2% of students, who focus on the subjects about Mendel genetics in spite of human genetic, can give right answer for genetic engineering definition (Wever, 1996).

The Attitudes of Students about Genetic Engineering Studies

Expressions asked to students about the engineering studies are divided into 4 sub group (see Table 4).

The f and % values of answers about revealing students attitude towards genetic engineering are summarized in Table 5. According to the expression group of the general statements about genetic studies answers in the attitude scale for revealing students attitudes about the genetic engineering studies, there is found no meaningful difference around the groups with One Way ANOVA test ($p > .05$). According to this, all

Table 2. Percentage values of answers to the question "what is genetic engineering according to the dissociation of majors and years"

DEFINITIONS	S.E. 3rd year		S.E. 4th year		B.E. 4th year		B.D. 4th year	
	f	%	f	%	f	%	f	%
It searches the genetic material's structure and function	27	25,5	12	33,3	29	67,5	3	12
Use of genetic material in different applications*	12	25	12	33,3	10	23,3	16	64
It examines heredity and variation	13	27,8	2	4,3	-	-	-	-
Offering the studies about the genetic material with technology for human benefit*	2	4,3	-	-	2	4,7	5	20
Other	32	8,5	2	4,3	2	4,7	1	4

* The answers which are accepted as right.

Tablo 3. Distribution of examples given by the students about the studies of genetic engineering according to majors and years

EXAMPLES	S.E. 3rd year		S.E. 4th year		B.E. 4th year		B.D. 4th year	
	f	%	f	%	f	%	f	%
Obtaining productive and resistant plant species	-	-	1	2,8	8	18,6	1	4
Gene maps	-	-	4	11	3	6,9	1	4
Gen transfer	2	4,3	-	-	3	6,9	6	24
Copying	27	57,5	17	47,2	13	30,2	10	40
Diagnosis and treatment methods of hereditary diseases	6	12,8	3	8,3	8	18,6		4
Obtain drug, vitamin etc. products from bacteria via gene transfer	-	-	-	-	4	9,3	5	20
Forensic cases	4	8,5	2	5,6	-	-	-	-
Watermelon without seed	1	2	1	2,8	-	-	-	-
Obtaining productive and resistant animal species	1	2	2	5,6	1	2,3	-	-
Other	6	12,8	6	16,7	3	6,9	1	4

Table 4. Distribution of statements in the attitude scale according to the groups

STATEMENT GROUPS	EXPRESSION NUMBER
The general statements about studies of genetic engineering	1, 2, 7, 10, 12
The statements about the genetic engineering studies with animals	3, 5, 6
The statements about the genetic engineering studies with plants	4, 8, 9
The statements about the genetic engineering studies with microorganisms	11

Table 5. Findings of the general expressions in about genetic engineering studies

STATEMENTS		S.E. 3rd year		S.E. 4th year		B.E. 4th year		B.D. 4th year	
		f	%	f	%	f	%	f	%
1. Genetic engineering makes human life easier	Y	37	78,7	28	77,8	39	90,7	23	92,0
	N.S	8	17,0	7	19,4	4	9,3	2	8,0
	N	2	4,2	1	2,8	-	-	-	-
2. Genetic engineering can provide opportunities for new discoveries	Y	44	93,6	34	94,4	43	100	25	100
	N.S	3	6,4	2	5,6	-	-	-	-
	N	-	-	-	-	-	-	-	-
7. The animal meats that obtained with genetic manipulations can be sold without giving any information to the consumer	Y	47	100	35	97,3	37	86,1	23	92,0
	N.S	-	-	1	2,8	6	14,0	2	8,0
	N	-	-	-	-	-	-	-	-
10. Transgenic organisms contain risks for nature	Y	-	-	4	11,1	2	4,7	5	20,0
	N.S	30	63,8	18	50,0	23	53,5	10	40,0
	N	17	27,2	12	33,4	18	41,9	10	40,0
12. Releasing GM organisms to nature without control contains risks	Y	15	31,9	8	22,3	8	18,6	4	16,0
	N.S	-	-	9	25,0	10	23,2	7	28,0
	N	32	68,1	19	52,8	25	58,2	14	56,0

Table 6. The findings of students answers to the statements about genetic engineering studies with animals

STATEMENTS		S.E. 3rd year		S.E. 4th year		B.E. 4th year		B.D. 4th year	
		f	%	f	%	f	%	f	%
3. The genetic engineering studies with animals are beneficial to people	Y	39	83,0	32	88,9	38	88,4	17	68,0
	N.S	7	14,9	2	5,6	5	11,6	5	20,0
	N	1	2,1	2	5,6	-	-	3	12,0
5. It is acceptable transfer genes that provide protein synthesis in sheep with the medical aim.	Y	1	2,1	-	-	-	-	-	-
	N.S	10	21,3	8	22,2	12	27,9	4	16,0
	N	36	76,6	28	77,8	31	72,1	21	94,0
6. Transfer of carcinogenic genes to mice with medical aim is acceptable	Y	-	-	-	-	2	4,6	-	-
	N.S	6	12,8	-	-	1	2,3	1	4
	N	41	87,2	36	100	39	93,1	24	96

the students, who join the research, have positive attitudes about the genetic engineering studies. However, 1st statement, which is one of the statements for revealing students general attitude about genetic engineering, is answered yes by 90.7 % of B.E. 4th year students and 92.8 % of B.D. 4th year students, while 78.7 % of S.E. 3rd year students and 77.8 % of S.E. 4th year students answer yes to the this expression. If the courses which are taken by students are determined; it is seen that while the students' knowledge level increase their risk perception and suspicion about the subject decrease.

If the answers of 2nd statement are examined; it can be thought that students perceive genetic engineering as a opportunity; on the contrary of general aspect in this field it is seen that all of the S.E. 3rd years students, 97.3 % of S.E. 4th year students, 86.1 % of B.E. 4th year students and 92 % of B.D. 4th year students think that the genetically changed organisms can be sold without giving any information to the consumers in markets.

If we examine the answers to the statement it is conspicuous that the answer rate of not sure is very high. This situation shows that students do not have sufficient knowledge about this topic. However, if the students answer to 10th statement and also to 12nd statement is examined; it is seen that most of the students think G.M. organisms do not have any risk for the nature.

Findings about students answer to the statement about their attitude about engineering studies with animals are summarized in Table 6.

Table 7. The findings of students' answers to the statements about genetic engineering studies with plants

STATEMENTS		S.E. 3rd class		S.E. 4th class		B.E. 4th class		B.D. 4th class	
		f	%	f	%	f	%	f	%
4. Gene transfer from animals to plants can cause plants to improve features like animals	Y	8	17,0	6	16,7	9	21,0	4	16,0
	N.S	18	38,3	8	22,2	22	51,1	9	36,0
	N	21	44,7	22	61,1	12	27,9	12	48,0
8. It is acceptable to produce plants with enrichment proteins	Y	-	-	-	-	-	-	-	-
	N.S	7	14,9	6	16,7	5	11,6	1	4,0
	N	40	87,2	30	72,3	38	88,4	24	96,0
9. It is acceptable to produce plants that synthesize substances with effective medical importance	Y	38	80,8	36	100	42	97,7	22	88,0
	N.S	6	12,8	-	-	1	2,3	1	4,0
	N	3	6,4	-	-	-	-	2	8,0

Table 8. The findings of students about Genetic engineering studies with microorganisms

STATEMENTS		S.E. 3rd class		S.E. 4th class		B.E. 4th class		B.D. 4th class	
		f	%	f	%	f	%	f	%
11. It is acceptable to provide lipase from the bacteria to use in detergents.	Y	17	36,2	19	52,8	25	58,2	17	68
	N.S	20	42,6	15	41,7	13	30,2	7	28
	N	10	21,2	2	5,6	5	11,6	1	4

If the students answer to the 3rd statement is examined; it is seen that without considering any distinction of students year and major, most of the students think use of animals in genetic engineering studies can provide benefits for people. However, if the answers of 5th and 6th statements are examined, it is seen that student oppose to using animals in genetic studies although it provide benefits to people.

Findings about students answer to the statements about their attitude about the genetic engineering studies with plants are summarized in Table 7.

If the findings about 4th statement are examined, it is seen that most of the students (approximately 80 % of them) answers about the statements are I am not sure and no, and there is not any difference between the groups ($p > .05$). If these rates are determined it appears that most of the research students do not have sufficient knowledge in this field. It is also interesting that the students who have optional genetic engineering course do not have sufficient knowledge about this statement too.

If the answers to the 8th statement are examined, it is seen that 87.2% of S.E. 3rd year students, 72.3% of S.E. 4th year students, 88.4% of B.E. 4th year students, 96% of B.D. 4th year students have negative attitude about production of plants with enriched proteins. However, 80.8 % of S.E. 3rd year students, all of the S.E. 4th year students find acceptable to the production of plants which can synthesize effective substances that have medical importance. This situation can be interpreted as students look positive to genetic changes in plants if it has medical importance (Table 8).

If the students answers to the 11th statement are examined; 36.2 % of S.E. 3rd year students, 52.8 % of S.E. 4th year students, 58.2 % of B.E. 4th year students and 68 % of B.D. 4th year students give "yes" answer. These rates show that most of students found acceptable of providing lipase enzyme from bacteria to use in detergents.

If students answers to the statements about using different organism groups for genetic engineering studies, are examined it is seen that students find less acceptable of genetic engineering studies with animals even if they have medical aims than the studies with plants and microorganisms. In Chen & Raffan (1999) and Lock & Miles (1993)'s studies there is encountered similar findings, it is established that students attitude show differences according to the objective and the type of organism that is used in application.

CONCLUSIONS AND IMPLICATIONS

Genetic engineering gets most of risks and disadvantages in spite of its advantages and benefits to human services. Because of this, today's young people, who will take obligation about social decisions in the future personally, have to be trained to have sufficient knowledge about this field is not sufficient at school level only and also at the social level (Moses, 2003; Schibeci, 2000).

If the findings of this study are examined, it is seen that the students who take courses about this field have more knowledge and they can give more examples about the studies than the students who do not take these courses. However, it is thoughtful that the answers given to the statements do not differ significantly between the students who take optional courses and the students who do not take any other courses than general genetic lesson. This result shows that genetics education does not focus enough on genetic engineering and its implications. From this point, to make lessons more meaningful and to provide more effective education, alternative teaching methods and strategies must take place frequently and the curriculum must be restructured to increase coverage of basic principles and applications of genetic engineering. Moreover, it is seen that students risk perception and negative suspects decrease while their knowledge level about this subject increase. This situation is made clear the importance of these lessons which will provide social conscious. Because of this besides giving basic knowledge; curriculum must be restructured to containing more about advantages, disadvantages and possible risks of the applications in different fields of genetic engineering, and programs that contain activities that will improve the student's ability to give a decision about ethical issues.

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APPENDIX

QUESTIONNAIRE

This questionnaire consists of 2 open ended questions and 12 statements about implications of genetic engineering and biotechnology. Please give a brief description for open-ended questions. You have totally 25 minutes to answer.

1. What is genetic engineering?
2. Can you give an example about the studies of genetic engineering?

Instructions: Please put a (√) for a response for each of the following statements.

1. Genetic engineering makes human life easier		
YES	**NOT SURE**	**NO**
2. Genetic engineering can provide opportunities for new discoveries		
YES	**NOT SURE**	**NO**
3. The genetic engineering studies with animals are beneficial to people		
YES	**NOT SURE**	**NO**
4. Gene transfer from animals to plants can cause plants to improve features like animals		
YES	**NOT SURE**	**NO**
5. It is acceptable transfer genes that provide protein synthesis in sheep with the medical aim.		
YES	**NOT SURE**	**NO**
6. Transfer of carcinogenic genes to mice with medical aim is acceptable		
YES	**NOT SURE**	**NO**
7. The animal meats that obtained with genetic manipulations can be sold without giving any information to the consumer		
YES	**NOT SURE**	**NO**
8. It is acceptable to produce plants with enrichment proteins		
YES	**NOT SURE**	**NO**
9. It is acceptable to produce plants that synthesize substances with effective medical importance		
YES	**NOT SURE**	**NO**
10. Transgenic organisms contain risks for nature		
YES	**NOT SURE**	**NO**
11. It is acceptable to provide lipase from the bacteria to use in detergents		
YES	**NOT SURE**	**NO**
12. Releasing GM organisms to nature without control contains risks		
YES	**NOT SURE**	**NO**