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Research article

Standing of biotechnology subjects found in biology courses of higher education and profiling of prospective teachers for their interests on biotechnology

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Abstract

In this study, profiling of prospective teachers for their interests on biotechnology in higher education institutions has been conducted and in conjunction with this, the extent of biotechnology subjects in the textbooks of higher education institutions has been investigated. A questionnaire has been prepared to reveal the educational level on biotechnology in higher education institutions and the interest whom prospective teachers have in biotechnology. The prepared questionnaire has been applied to 100 prospective teachers receiving education in the Departments of Physics, Chemistry, Biology, and Applied Sciences Education in Kazim Karabekir Faculty of Education at Ataturk University. As a result of the questionnaire applied to prospective teachers, it has been determined that 54% of the prospective teachers are fond of the subjects related to biotechnology. Also, the assessment carried out for showed that most of the prospective teachers (65%) recognize the importance of biotechnology but also they believe that the subjects of biotechnology in higher education are not covered enough and the information given is not sufficient and the necessary explanations are not made about its importance.

Keywords: *Ataturk University; biotechnology subjects; higher education; prospective teachers; questionnaire*

1. Introduction

Applied sciences, namely biology, chemistry and physics, are disciplines that utilize existing scientific knowledge to develop more practical applications, technology, or inventions (Ozyigit, 2020a). Therefore, any advances in these disciplines directly affect people's futures. This puts forth the importance of the education of applied sciences students. Application of modern science and technology in education depends on the removal of conservative and dogmatic thoughts (Klimenko, 2017; Chowdhury, 2018; Bakholskaya et al., 2020). Nowadays, science and technology, along with molecular biology and biotechnology within life sciences are progressing rapidly (Arvas and Kaya, 2019).

While nature is being destroyed by humans unconsciously, natural resources are being depleted, environmental pollution

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occurred (Turan et al., 2020; Yalcin et al., 2020). Natural environments are influenced by industrial and human activities and contaminated with harmful organic contaminants such as polycyclic aromatic hydrocarbons (PAHs), insecticides, herbicides and both organic (i.e. hydrocarbons, different solvents, petroleum products, pesticides, herbicides, polychlorinated biphenyls, phthalate esters, phenols, and their derivatives) and inorganic contaminants include heavy metals and metalloids such as arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), lead (Pb), mercury (Hg), nickel (Ni), manganese (Mn), molybdenum (Mo) and zinc (Zn) (Gupta et al., 2020; Hocaoglu-Ozyigit and Genc, 2020). Having said that, an alternative eco-friendly perspective must be established so as biological control can be effectively used for organisms (Akcay and Kaya, 2019; Bahaman et al., 2020; Oyewusi et al., 2020).

The dramatic changes mentioned above made it a necessity to increase the researches in applied sciences branches and for well-educated scientists to focus on the solutions for these problems. In recent years, advances in biotechnology have shown promise in finding solutions to these problems via biotechnological methods and thus, training knowledgeable and sufficient people, who will work in problem solving using biotechnological applications, became a requirement. Also, improvement in observation, experimentation, analysis, synthesis and decision-making skills of candidate teachers is needed. The best way for this is to emphasize laboratory studies in the curriculum of physics, chemistry, biology and applied sciences education departments (Jeronen et al., 2017; Kumandas et al., 2019). Biology and consequentially biology education both including biotechnology, has priority among these science branches.

The word biology consists of two words; bios (living) and logos (science) and refers to the "science of life". Although the term "biology" was used by Roos in 1797, Burdach in 1800, and Lamarck and Trevianus in 1802, scientific researches in the field literally started 25-30 years later. The progress was amazing in a short period of 150-200 years, after the discovery of cell (Gardner, 1965; Serafini, 2013; Ozyigit, 2020a; Urry et al., 2020).

Today, biology has many branches such as anatomy, astrobiology, biotechnology, biochemistry, bioinformatics, biolinguistics, biological anthropology, biological oceanography, biomechanics, biophysics, botany, cell biology, developmental biology, ecology, ethology, evolutionary biology, genetics, histology, immunology, microbiology, molecular biology, neuroscience, paleontology, physiology, population biology, quantum biology, structural biology, synthetic biology, systems biology, theoretical biology, toxicology and virology (Ozyigit, 2020a).

Biotechnology is defined as the science that uses biological systems, living organisms, or parts of these to improve or create diverse products (Fári and Kralovánszky, 2006). With another definition, "Study of combination of both the living organism or their parts and a group of technologies to develop or make different products to improve the quality of human life" (Ozyigit, 2020a). Currently, biotechnology has a wide field of application and has many benefits for human life and all living organisms. Briefly, biotechnology covers the use of various biochemical and physiologic properties of microorganisms, cells and tissues mostly in cultured forms for practical purposes, gene recombination for obtaining desired features, remediation with organisms, in fields like agriculture, forestry, food industry, medicine, pharmacy, and even military (Ozyigit, 2012, Ozyigit et al., 2013; Arvas and Kaya, 2019; Bahaman et al., 2020; Muslem et al., 2020; Wahhab et al., 2020).

In fact, people used biotechnology for their daily activities such as bread yeasting, vinegar and yogurt production, as well as making clothes and shelters since ancient times. However, with the advancement of biological techniques together with other science branches, microbiology, biochemistry, genetics, molecular biology, omics technologies, bioinformatics became the base of biotechnology today (Kaya et al., 2013; Filiz et al., 2017; Arvas and Kaya, 2019; Ozyigit, 2020a; Samsulrizal et al., 2020).

A special and remarkable field of application in biotechnology, recombinant DNA technology, is broadening peoples' horizon in sciences such as medicine, food technology, pharmacology and agricultural biotechnology, and providing large amount of benefits, as well (Johnson, 1983; Akalin, 2020; Gul, 2020; Plavec and Berlec, 2020; Tomic et al., 2021).

Recombinant DNA techniques and modern biotechnology can be applied to form proteins and genes that are not normally produced in a cell. Also, bacteria and living organisms carrying recombinant DNA can be released to the natural world to increase the fertility of the soil, can serve as an insecticide, used for molecular farming, biopharming or relieving pollution (Abdul et al., 2019; Hasan and Manan, 2020; Subramaniam et al., 2020). Microorganism research is now in the field of interest of food biotechnology, medicine, agriculture etc. (Cetinkaya et al., 2020; Ozyigit, 2020b; Ozyigit et al., 2020).

Some scientific works that have already been done using biotechnological methods and some possible future studies are; (1) obtaining plants resistant to biotic and abiotic stress and containing more nutritious products, (2) obtaining and raising healthier, productive, disease-resistant livestock, (3) transferring edible vaccines in food products, (4) environmental cleaning with transgenic organisms, (5) research and development of new drug formulations, especially obtaining delayed-release type formulation development, (6) obtaining recombinant therapeutic agents, diagnostics for infectious and genetic diseases and artificial organs and tissues, (7) development of specific gene delivery vectors and DNA vaccines and gene therapy, (8) identification of drug candidates with the help of the bioinformatics and genetic applications and (9) utilization of biotechnology in preclinical research and development (Arvas and Kaya, 2019; Akalin, 2020; Carvalho et al., 2020; Gul, 2020; Ozyigit, 2020b; Ozyigit et al., 2020; Plavec and Berlec, 2020).

Nowadays, keeping up with advancements in biotechnological fields has become a necessity. Turkey is rich in biotechnological raw materials and these should be used in the best way by entrepreneurs and institutions. This situation shows us that related branches of universities such as biology and life sciences should be supported in terms of knowledge and finances.

This work aims to determine the levels of biotechnology knowledge in lessons of higher education branches and the interest of prospective teachers in biotechnology.

2. Materials and methods

In order to determine the extents to which biotechnology subjects are included in the courses, the textbooks of which used in departments of Physics, Chemistry, Biology, and Applied Sciences Education in higher education were examined. Also, a surveillance research as a questionnaire was prepared to reveal the interest prospective teachers have on biotechnology subjects. The questions of the survey used to inquire about the interest of prospective teachers having can be seen in the results section.

2.1. Evaluation questionnaire

The questionnaire prepared was applied to the 100 prospective teachers receiving education from the four departments in Kazim Karabekir Faculty of Education at Ataturk University, Erzurum, Turkey. The departments and the number of students that survey performed were presented in Table 1. Due to considering as of an interfering factor, prospective teachers were chosen as half and half regarding with sex.

Table 1
Distribution of prospective teachers in the departments.

Department	Number of students (n)	Percentage (%)
Biology Teaching	34	34
Physics Teaching	22	22
Chemistry Teaching	24	24
Applied Sci. Teaching	20	20
Total	100	100

3. Results and discussion

3.1. Standing of where biotechnology subjects found in biology courses in the programs of higher education

The textbooks used in the programs of higher education were examined in this work. As a result of the examination, the subjects related with biotechnology were found to be in the contexts of these textbooks (in some extents) taught in the courses.

3.2. Evaluation of the prospective teachers receiving education in terms of their interests in biotechnology

The following questions below were asked to find out what extent the prospective teachers were interested in biotechnology subjects. The obtained results were evaluated and presented below.

3.2.1. Do the prospective teachers receiving education find the subjects of biotechnology in the programs of higher education interesting and current?

The opinions of the prospective teachers about whether they find the subjects related to biotechnology included in the curriculum of higher education up-to-date and interesting or not were given in Table 2. Of the prospective teachers who answered the question, 21% said that I find it definitely up-to-date and interesting, 35% said that I would be very interested, and 23% would be moderately interested. On the other hand, the rate of the prospective teachers who said "I have little interest on biotechnological subjects" was 13% while 8% of the prospective teachers answered as "I don't care".

Table 2
The interest of prospective teachers having on biotechnology subjects.

Agreement	Number of students (n)	Percentage (%)
Definitely agree	21	21
Agree	35	35
Partly agree	23	23
Don't agree	13	13
Definitely don't agree	8	8
Total	100	100

3.2.2. Questions about inviting qualified persons for providing attraction on biotechnology issues to prospective teachers receiving education

The question about whether qualified persons to be invited for a seminar in order to provide attraction on biotechnology issues to prospective teachers and the answer that given for the question were given in Table 3. 87% of the prospective teachers' thought asked for inviting a qualified person for a seminar in order to provide attraction on biotechnology issues were positive as the answer, while 16% was moderately (partly) agree. Whereas, the rest of them gave negative answer for the proposal.

Table 3
Invitation of a qualified person for a seminar in order to provide attraction on biotechnology issues.

Agreement	Number of students (n)	Percentage (%)
Definitely agree	28	28
Agree	43	43
Partly agree	16	16
Don't agree	8	8
Definitely don't agree	5	5
Total	100	100

3.2.3. When prospective teachers were asked for, should biotechnology issues be comprised in greater extent in the relevant textbooks?

In Table 4, the answers from prospective teachers were presented for the proposal related with whether biotechnology issues should be comprised in greater extent in the relevant textbooks. 86% of the prospective teachers participating in the questionnaire was agree about comprising biotechnology issues in greater extent in the relevant textbooks. Among them, 29% was partly agree. On the contrary, 14% stated that the information given was sufficient on biotechnology subjects.

Table 4
The percentages of the answers given related with whether biotechnology issues should be comprised in greater extent in the relevant textbooks.

Agreement	Number of students (n)	Percentage (%)
Definitely agree	17	17
Agree	40	40
Partly agree	29	29
Don't agree	11	11
Definitely don't agree	3	3
Total	100	100

3.2.4. Biotechnology related subjects present in the curriculums

The answers given by the prospective teachers to the question of whether they care of the subjects related to biotechnology in the curriculum or not were presented in Table 5. The results showed that 12% of the prospective teachers states of having care for very much, 42% of them states of having care for fairly well and 25% of them states of having care for little interest. And, 21% of them states of having no care.

3.3. The opinions of prospective teachers about whether wishing to participate in laboratory exercises in biotechnology related subjects

The answers given by the prospective teachers to the question of whether they care of whether wishing to participate in laboratory exercises in biotechnology related subjects were pre-

sented in Table 6. While 17% of the prospective teachers said that they would participate in the laboratory exercises with pleasure, 32% of them said that they could participate, and 37% of them said that caring to participate in some sense. And, 14% of them said that do not wishing to participate.

Table 5
The percentages of whether caring of biotechnology subjects in the relevant textbooks or not being in the curriculums.

Agreement	Number of students (n)	Percentage (%)
Definitely agree	12	12
Agree	42	42
Partly agree	25	25
Don't agree	10	10
Definitely don't agree	11	11
Total	100	100

Table 6
The opinions of prospective teachers about whether wishing to participate in laboratory exercises in biotechnology related subjects.

Agreement	Number of students (n)	Percentage (%)
Definitely agree	17	17
Agree	32	32
Partly agree	37	37
Don't agree	9	9
Definitely don't agree	5	5
Total	100	100

3.3.1. Interest of the prospective teachers having about whether willing to participate on the research related with milk and cheese production using microorganisms

The information collected on the interest of the prospective teachers participating in the questionnaire in investigating milk and cheese making using microorganisms was presented in Table 7. 18% of the prospective teachers stated that they are definitely interested to involve in such a research. 38% of them was agree and 27% was partly agree. The rate of prospective teachers who are not very interested in this issue was 17%.

Table 7
Interest of prospective teachers in research related with milk and cheese production using microorganisms.

Agreement	Number of students (n)	Percentage (%)
Definitely agree	18	18
Agree	38	38
Partly agree	27	27
Don't agree	11	11
Definitely don't agree	6	6
Total	100	100

3.3.2. Interest of the prospective teachers having about whether willing to participate on the research related with altering dangerous microorganisms into non-dangerous states

In Table 8, it is stated whether the prospective teachers take care of participating in a research related with altering hazardous microorganisms into non-hazardous states. While 26% of the prospective teachers who wants to participate in such research as saying definitely yes, 31% of them stated that they would like to participate, and 19% of the stated that they did not want to participate.

Table 8
Interest of prospective teachers in research related with altering dangerous microorganisms into nondestructive forms.

Agreement	Number of students (n)	Percentage (%)
Definitely agree	26	26
Agree	31	31
Partly agree	29	29
Don't agree	9	9
Definitely don't agree	10	10
Total	100	100

3.3.3. Prospective teachers' opinions on the use of microorganisms in medical research

The opinions of the prospective teachers having whether interest to participate in the research related with the use of microorganisms in medical research was presented in Table 9. While 18% of the prospective teachers who absolutely wants to participate in such research, 35% of them stated that they could participate, 24% was moderately agree and 23% of them stated that they would not participate.

Table 9
The information taken as the prospective teachers' opinions on the use of microorganisms in medical research.

Agreement	Number of students (n)	Percentage (%)
Definitely agree	18	18
Agree	35	35
Partly agree	24	24
Don't agree	17	17
Definitely don't agree	6	6
Total	100	100

3.3.4. Whether the prospective teachers are willing to participate in the research about converting hazardous wastes into non-hazardous forms using microorganisms.

The answers given by the prospective teachers to the questions about the research of converting hazardous wastes into non-hazardous forms were given in Table 10. 79% of the prospective teachers stated that they wanted to participate in such a study and 23% of them stated that they could participate in part. 8% of them stated that they could never participate.

Table 10
Interest of prospective teachers in research related with converting hazardous wastes into non-hazardous forms using microorganisms.

Agreement	Number of students (n)	Percentage (%)
Definitely agree	21	21
Agree	35	35
Partly agree	23	23
Don't agree	13	13
Definitely don't agree	8	8
Total	100	100

3.3.5. Prospective teachers' opinions on employing microorganisms in establishing of bio-gas facilities

The answers given by the prospective teachers to the question about possibility of their involvement in researches in establishing of biogas facilities were given in Table 11. 32% of the prospective teachers says yes as they could definitely participate

in such works, 21% of them stated that they could participate, 20% of them says yes in part, and 27% of them says no.

Table 11
Possibility of prospective teachers to participate in a study related with using microorganisms in the establishment of biogas facilities.

Agreement	Number of students (n)	Percentage (%)
Definitely agree	32	32
Agree	21	21
Partly agree	20	20
Don't agree	15	15
Definitely don't agree	12	12
Total	100	100

3.3.6. Prospective teachers' opinions on the gene therapy related issues including modifications of genes that cause hereditary diseases in humans

The answers given by the prospective teachers to the question about possibility of their involvement in researches on the gene therapy related issues including modifications of genes were given in Table 12. 52% of the prospective teachers stated that they can willingly participate in such a research, 26% of them stated that they can participate in part, and 22% of them stated that they are not interested at all.

Table 12
Prospective teachers' opinions whether want to involve or not in gene therapy oriented researches.

Agreement	Number of students (n)	Percentage (%)
Definitely agree	16	16
Agree	36	36
Partly agree	26	26
Don't agree	13	13
Definitely don't agree	9	9
Total	100	100

3.3.7. Prospective teachers' opinions on the issues related to the use of biotechnology in plant breeding researches

The answers given by the prospective teachers participating in the survey to the question about the use of biotechnology in plant breeding studies were presented in Table 13. 29% of the prospective teachers stated that they prefer to participate in such a research, 28% of them stated that they could join to such a research in part, and 43% of them stated that they do not want to involve.

Table 13
Possibility of prospective teachers to participate in a research related to the use of biotechnology in plant breeding researches.

Agreement	Number of students (n)	Percentage (%)
Definitely agree	11	11
Agree	18	18
Partly agree	28	28
Don't agree	28	28
Definitely don't agree	15	15
Total	100	100

3.4. Prospective teachers' opinions regarding whether they were gained competent knowledge about biotechnology during the secondary and high school education years

The prospective teachers' opinions on the question of whether they had gained competent knowledge about biotechnology during the secondary and high school education years were given in Table 14. 10% of the prospective teachers participating in the survey stated that they definitely gained adequate knowledge about biotechnology during the secondary and high school education years, 42% of them said that they gained rather less, and 18% of them said that definitely did not gained.

Table 14
Consideration of whether prospective teachers were gained competent knowledge or not about biotechnology during the secondary and high school education years.

Agreement	Number of students (n)	Percentage (%)
Definitely agree	10	10
Agree	23	23
Partly agree	19	19
Don't agree	30	30
Definitely don't agree	18	18
Total	100	100

In this study, the standing of where biotechnology subjects found in biology courses in higher education was investigated. For this purpose, general biology 1, 2, 3, and 4, environmental health, microbiology, genetics, mathematics, general physics, general chemistry and environmental chemistry textbooks were examined in terms of whether covering biotechnology related subjects.

As a result of the examination, it was found that there are some subjects related to biotechnology in the books that are read in the higher education curriculums in our country. The courses that include the subjects related to biotechnology (applications of molecules play roles in biotechnology, tools used in biotechnology, wastewater treatment strategies, recombinant DNA technology etc.) were found to be general biology, microbiology, genetics, and environmental health.

Achieving progress in biotechnology as in every field depends on the studies included in higher education programs. According to the results of the survey conducted to determine prospective teachers' interest in biotechnology, 79% (23% in part) of the prospective teachers find biotechnology-related subjects interesting and up-to-date. In the study, as definitely and/or fairly well, 71% of the prospective teachers agreed on inviting qualified persons to give seminars and providing up-to-date information on biotechnology. According to our results, 57% of prospective teachers want biotechnology subjects extensively to be included in the textbooks of higher education that indicates the need for covering more information on biotechnology subjects. Besides, 54% of the prospective teachers said that they enjoy with the subjects related to biotechnology in the curriculums.

When the prospective teachers were asked whether they would like to participate in laboratory researches with having different goals, 49% of them wants to participate as definitely and/or fairly well and 37% of them wants to participate in part. The results show that as definitely and/or fairly well; 56% of them wants to participate in researches involving in productions of milk and cheese using microorganisms; 57% of them stated their willingness to participate in researches involving modification of dangerous microorganisms into non-destructive forms; 53% of them wants to participate in researches involving in productions of vaccine, antibiotics, vitamins and enzymes using microorganisms; 56% of them prefer to join into researches regarding with converting hazardous wastes into non-hazardous forms using microorganisms; 53% of them care about involving

in researches related with obtaining gases such as methane and ethane using microorganisms.

The prospective teachers were asked whether they would like to take part in a research involving gene therapy related issues including modifications of genes that cause hereditary diseases in humans, 52% of them stated their agreement as definitely on the subject. Additionally, 29% of them wants to join into researches involving carrying out plant breeding activities.

In the study, 33% of the prospective teachers stated that biotechnology related subjects were not being covered enough in the time period of their secondary and high school; therefore, they stated that they do not have comprehensive knowledge on biotechnology subjects. This showed that biotechnology related subjects should be covered in a more way in secondary and high school education. Additionally, 2% of the prospective teachers stated that they are at least a member of a current academic and biotechnology journal. This reveals the fact that the level of biotechnological researches being performed is not quite enough and the students receiving education at universities do not have consciousness about the importance of biotechnology.

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