

Letters

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Knowledge of Elementary Genetic Terminology Among High School Students in Bosnia and Herzegovina

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Abstract

Genetics, as a science of the future, is very important part of Biology teaching. Within educational system in Bosnia and Herzegovina it is studied in limited number of classes with a minimum of practical exercises, in both elementary and secondary schools. Limited understanding of scientific facts result in prejudices or uninformed attitudes towards novel biotechnologies that are largely based on non-reviewed and non-scientific information often incorrectly or inadequately presented in mass-media. Purpose of this research was to estimate the level of knowledge about selected topics in genetics among high school students in three Mostar high school institutions and differences in the level of knowledge between students from different high school programs – grammar school and vocational medical school. The research was conducted in 2017 among students of fourth grade of three high school institutions: "Grammar School Mostar", "Medical high school Mostar" and Medical high school "Sestre milosrdnice". Notable differences in knowledge level between two vocational programs are observed as well as variance in learning outcomes of the same program presented in two formal languages in Bosnia and Herzegovina.

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Introduction

As an integral part of biology, genetics is an object of studying in elementary and secondary schools and every person should be aware that it is a relatively

young field of science. Genetics is the study of inheritance and studies how traits are passed on to offsprings, how they are maintained, changed and manifested under the influence of external and/or internal factors. Its core area of research is a gene, as the basic unit of inheritance. Genetic studies provide the explanation of the emergence and frequently enable treatment of many hereditary and other serious diseases, tumors for example. Apart from medicine, genetic studies hold important position in pharmacy, biochemistry, but also in agriculture,

veterinary, food industry, criminology and judiciary. Another reason is a professional orientation of students, because genetics is perceived as a science of the future, therefore it is particularly attractive to students.. Already, in the European biopharmaceutical sector, the production of 20% of drugs is partially or fully based on biotechnology. Also, a growth of 10% per year is estimated for biotechnology of marine resources (Ministry of science and education and AMPEU, 2013). Today, consultation of genetics experts is a normal occurrence in family planning in groups with established risk of heritable diseases, in the determination of paternity, tissue transplantation, blood transfusion, immunohistochemistry in the diagnostics and characterization of oncological diseases. Additionally, genetic consultations are useful in the production of antibiotics, vaccines, insulins, and agricultural crops that may be more resistant and better adapted to the environment. The newest trends promote the use of expensive genetic tests that can pinpoint a person's affinity for any given sport, or even enable use of so called genetic doping (Neuberger & Simon, 2017). There are now growing concerns regarding possible misuse of gene technology and the audacity to "play God". In December 2015 at International Summit On Human Gene Editing in Washington ethical and scientific issues regarding the gene editing of human embryo genome were discussed. Since then experiments were allowed in a few countries (Frey, 2014). Genetics and molecular biology are on the list of top 162 jobs in the world until 2030. High school education system of Federation of Bosnia and Herzegovina allows for 30 hours of genetics within Biology curriculum in the second grade only. Classes are almost exclusively theoretical, with limited number of experimental demonstrations. According to the unpublished data from student affairs office, there is a positive annual trend in the number of students enrolled in this field at the Faculty of Science of University of Sarajevo as a biggest higher education institution offering Bachelor study program in Genetics in Bosnia and Herzegovina.

Purpose of this research was to estimate the level of knowledge about selected topics in genetics among

high school students, attending different classes in biology according to different teaching and language programs, in three Mostar high school institutions and to evaluate possible differences in the level of knowledge between students from different high school programs – grammar school and vocational medical school.

Materials and methods

The research was conducted in 2017 among the fourth grade students of three high school institutions in Bosnia and Herzegovina: "Grammar School Mostar", "Medical high school Mostar" and Medical high school "Sestre milosrdnice". The three selected schools implement different curricula. All of them have 70 hours of biology per one school year (2 hours per week) with approximately 30 hours of genetics over the course of four years. The study included 203 high school students who received and completed written survey. The survey contained 19 questions covering different topics in genetics that are taught within all high school programs. The questions were divided into four sections: „cell and genetic structure“ (8 questions), selected heritable disorders in humans (4 questions), cloning and genetic modifications (5 questions) and influence of genetics on metabolism of drugs (pharmacogenetics) (1 question). The answers were scored as 1 – correct or 0 – incorrect. The total score per student for questionnaire and each of four sections were taken into account in comparison between analysed groups using two sampled paired t-test contained in the PAST software v.3.2. (Hammer et al., 2001).

Results and Discussion

Total of 203 high school students from three Mostar high schools participated the predesigned survey which comprises around 90% of total population of fourth graders in respective schools. Total score (number of correct answers) or knowledge on genetics was higher among students of grammar school in relation to their colleagues from medical vocational secondary schools. This difference was statistically different ($t=-3,3025$; $P=0,0006$) (Fig. 1). The overall difference is a result of difference in

knowledge on specific groups of questions: Cell and Genetic structures (Section 1 questions) ($t= 4,2974$; $P<0,0001$) and Section 2 questions about inherited

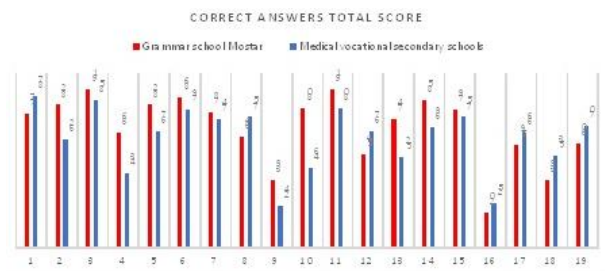


Figure 1. General knowledge difference on genetics was higher among students of grammar school in relation to their colleagues from medical vocational secondary schools was statistically significant ($P=0.0006$)

disorders in humans ($t=2,7643$; $P=0,0031$) (Fig. 2). Statistically significant differences in knowledge of Cloning and Genetic modifications (Section 3 questions) and Pharmacogenetics (Section 4 questions) were not observed.

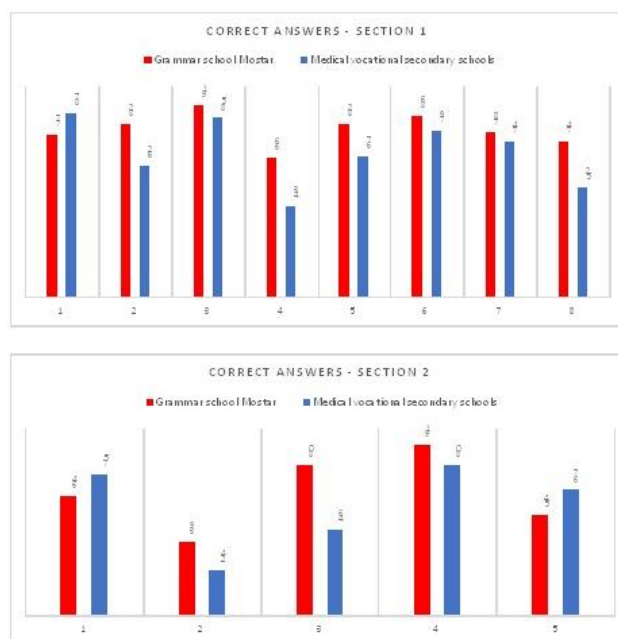


Figure 2. Overall difference in correct answers - Section 1 (Cell and Genetic Structures) and Section 2 (Inherited disorders in humans) were statistically significant (1- $P<0.0001$; 2- $P<0.0031$). Section 3 (Cloning and Genetic modifications) and Section 4 (Pharmacogenetics) were not statistically significant

Further analysis of knowledge differences among specific language programs of Grammar school program (Croatian and Bosnian) pointed single difference on topics from Section 1 or Cell and Genetic Structures ($t=-1,8466$; $P=0,028$) (Fig.3),

while in other question sections significant differences were not observed. The students following different language programs in medical vocational school showed insignificant difference in knowledge of elementary terms in genetics.

Additional analysis was made to assess openness towards novel biotechnology products where less than half or 36 – 41% participants responded positively. The same relation between correct/incorrect answers is noticed in questions about influence of genetics on drugs metabolism and recognition of products derived of GMO technology.

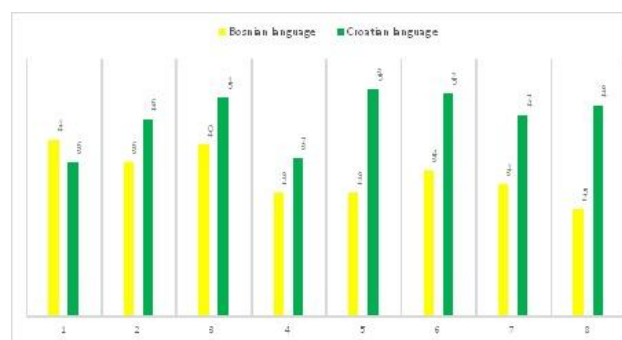


Figure 3. Analysis of knowledge level differences among specific language programs of Grammar school program Croatian and Bosnian pointed single difference on topics from Section 1 or Cell and Genetic Structures ($P=0.028$). In other question sections significant difference was not observed

When we analyzed answers in all the categories of questions in genetics, we noticed statistically significant difference in the level of knowledge between students of grammar school and medical vocational schools. The reason for that could be the differences in programs or the implementation methodology between different high school programs. Interestingly, the negative attitude towards novel biotechnologies is dominant in whole student population. In a similar research, published in 2005, conducted in a larger sample of high school students in Brazil, students were relatively well informed about some of the main issues related to the applications of genetics. They believed that transgenic food could be useful and should be encouraged and they were strongly supportive of the labeling of transgenic food (Neuberger & Simon, 2017). The reason for that could be the fact that Brazil has a clear strategy in biotechnology development and that high school awareness is affected by

general population trends. Similar results on the issue of knowledge of biotechnology in youth (high school and university students), were found in research conducted in Turkey (Usak et al, 2009). Their results suggested that although students' appreciation of (agricultural) biotechnology was relatively positive, the understanding of biotechnological processes was superficial and attitude toward purchase of genetically modified products was therefore negative. The possible impact of current science and biology curriculum, and also biotechnology news given in media on Turkish students' views of biotechnology was hypothesized.

Conclusions

Knowledge of basic terms in the field of genetics, within high school student population in Mostar, was average overall. The level of knowledge in elementary genetics terms significantly differed between students who attended grammar school as compared to medical vocational school. This difference is due to statistically significant difference in knowledge about Cell and Genetic structures as well as about inherited disorders in humans. The different level of knowledge is not expected as there is no significant difference in content and scope in genetics curricula between grammar school and medical vocational school. The observed differences are probably due to teaching methodology and student intrinsic motivation. In order to harmonize the effects of teaching outcomes, introduction of experimental demonstrations is recommended. Also, the theoretical knowledge on cell and genetic structures and the most common heritable diseases in humans need improvement. There is a strong need for redefinition of basic genetic terminology in context of high technological advancements in the field and improvement of teaching methodology through lifelong learning schemes. For the purpose of improving knowledge, it is also desirable to popularize this field through scientific programs in mass-media.

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