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High School Students' Attitudes Towards Learning Genetics and Belief in Genetic Determinism

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Abstract: Students in high school tend to find genetics difficult to learn because it requires some crosslinked knowledge about subjects like genes, proteins, cells, tissues as well as organs and systems. It also becomes more difficult to connect and explain concepts such as the gene expression at the level of the cell to conceptualize the effect of the gene at the level of the organism. On the other hand, despite the fact that molecular genetics has progressed rapidly, its reflection in textbooks or even the qualifications of teachers in relation to the latest findings in genetics, have not responded to this pace. Here we present a survey study of Albanian high school students (grades 10-12, ages 15-19) on their attitude study genetics and their beliefs towards genetic determinisms. A number of 274 students participated in the survey, from 8 different public and private schools in the country. The response rate was higher than 90% for each group, 58.4% of the respondents were females, 32.6 0% were males and 4.1% did not answer. The mean age of the respondents was 16.8 (± 1.8) years. Students found genetics interesting, and relevant but also a difficult topic in biology (respectively: 36.5%; 33.2%: 39.2%). Their responses showed positive attitudes towards gene technology and acceptance of the use of gene editing (51.4%). Students' perception of the utility of genetics did not differ among them; female and male students had significantly different responses along attitude factors, however liking genetics was the only factor without gender difference. Our study suggests that in general students liked to study genetics and they had mostly favorable attitude towards gene technology. They are not completely convinced of genetic determinism; this is also made possible by updated books. A complete study combining the textbooks, the knowledge of the teachers, and their approaches are needed.

Keywords: Education, Survey, Genetic determinism, Genetics, Students

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Introduction

The relationship between determinism, knowledge, attitudes and beliefs about genetics is unclear. Most of the studies have focused on aspects of genetics or genomics use. In the last two decades, however, research in genetics has evolved into genomics and our understanding of genes and genomes and how they relate to development, phenotypic traits, cell physiology, among other features, has radically changed (Meyer et al., 2012 ;El-Hani et al., 2007).

We are living in an exciting time regarding the way the genome of different organisms is being explored, including the human genome. This way of scientific research, thanks to advanced technology, has increased the need for understanding genetics and its terminology.

The steps which the science of genetics is enriching this literacy are much faster than the material that is reflected in the textbooks. In our country, only in the last 10 years, new texts have begun to be implemented that reflect some of the achievements in this science.

On the other hand, in the high school level, age group 15-19 years old, several types of schools operate in our country. Public secondary schools, where the textbooks are suggested and are uniform, private secondary schools, where the textbooks are optional according to the programs that these schools offer, and professional schools of a technical nature, which use the same texts as public schools but with a reduced program.

At the same time, teachers have a role in teaching the science of biology in general and genetics in particular. The teacher uses different emphases in teaching genetics (Aivelo et al., 2019). The engagement of students in extracurricular topics depends entirely on the teacher's training.

The teachers admitted that in the textbooks high school students have scientific concepts about biological determinism, genetic determinism, and environment determinism. This programme combines the doctrine that: “human and nonhuman animal behavior and mental activity are largely (or completely) controlled by the genetic constitution of the individual and that responses to environmental influences are for the most part innately determined. the concept that psychological and behavioral characteristics are entirely the result of constitutional and biological factors. Environmental conditions serve only as occasions for the manifestation of such characteristics. the view that psychological and behavioral characteristics are largely or completely the result of environmental conditions. Biological factors are considered to be of minor importance, exerting little if any influence” (Meyer et al. 2012).

The questions that arise, for these issues that may have remained un-reflected in the textbooks, are motivated by seeing the level of students who come to study Biological Sciences in the Faculty of Natural Sciences. For this reason, we undertook the first study of this kind in our country, to understand how these achievements in the

science of genetics have been reflected in the perception and attitude.

Here We present a survey study of Albanian upper secondary school students (grades 10–12, ages 15–19) on their attitudes towards studying genetics and the use of gene technology, and belief in genetic determinism.

Method

Questionnaire

We collected questionnaire data from the students during the school year 2023–2024, time of the active practical part of our master students, when they are permanent resident in different schools and collaborate with teachers to present the questionnaire to the students during the school day throughout the school year. They choose to collect the questionnaire during the second semester after the students had finished the topics related to cells and heredity as well as gene concepts and biotechnology. To study the students' attitudes and beliefs, we composed a survey based on (Aivelo & Anna Uitto 2021), with modification. We combined 18 questions to measure students' attitudes towards learning Genetics science and their perception for genetic determinism. We include one short exam to see how they understand the correlation between genotype and phenotype.

Data collection and study group

The population of interest included upper secondary school students (grades 10–12, ages 15–19). The questions were organized into two sections; the first section included questions on the students' demographic and type of school, and the second section asked students about their perception, attitude, and beliefs in genetics determinism.

The questionnaire was made available to the students by their teacher during an extracurricular lesson after finishing the chapters on the cell and inheritance. This way the survey ensured us a high participation of more than 90%. Participants were from private high schools (98 students); public high schools (128 students), and professional high schools (18 students). A total number of 274 students participated in the survey, from 8 different public and private schools in the country.

Statistical Analysis

The data preprocessing step and statistical analysis were performed in SPSS 26.0. The data is first explored using frequencies, descriptive statistics, and graphical visualizations. Chi-square test is used to test the relationships between general features of the respondents and several selected nominal variables in the questionnaire. Spearman Correlation is used to estimate the correlation between ordinal variables and the chi-square goodness-of-fit test is used to determine whether the distribution of cases in a single categorical variable was equal across categories.

Results

General information about study group

The results showed that a number of 274 students participated in the survey, from 8 different public and private schools in the country. The response rate was higher than 90% for each group, 58.4% of the respondents were females, 32.6 0% were males and 4.1% did not answer. The mean age of the respondents was 16.8 (± 1.8) years (Figure 1)

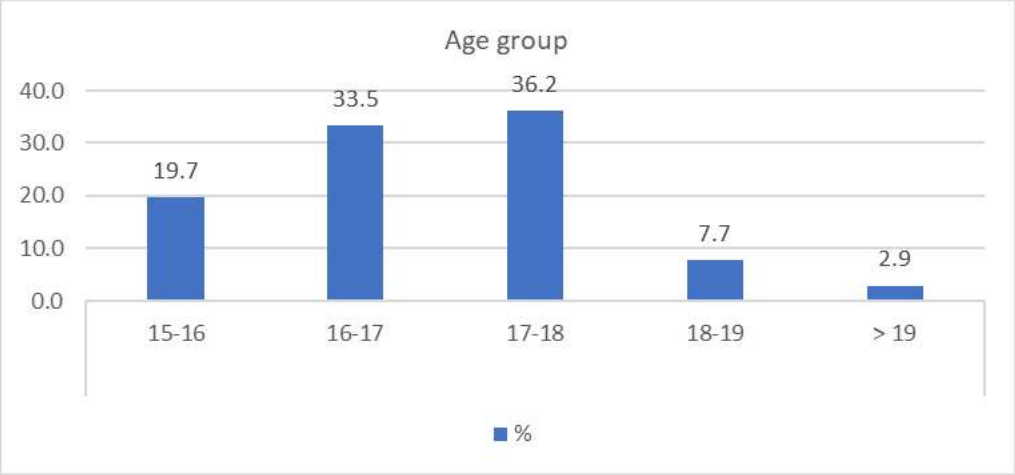

Figure 1. Distribution of participants according age group

According to the type of school and other demographic data, our sampling consists of 57.6 % public schools, 35.8% private schools and 6.7% professional schools. Most of the participants study in schools in Tirana (90.8%) and only 9.1 % in the districts (Table 1). The distribution of the questionnaire in all the districts of Albania was difficult at this time of the study, but this is a goal for the future extension of this survey.

Table 1. Demographic data about study group

Variables		N	Frequency %
Type of school	Public	158	57.6
	Private	98	35.8
	Professional	18	6.7
Gender	F	160	58.4
	M	86	31.6
Residency	Tirana	249	90.8
	Other districts	25	9.1

Perceptions about genetics

Students found genetics interesting, and relevant but also a difficult topic in biology (Table 2).

Table 2. Considerations of perceptions about genetics

Statement	Strongly disagree (%) N	Disagree (%) N	Agree (%) N	Strongly agree (%) N
Genetics is a difficult area of biology	(10.2)28	(20.0)55	(37.2)102	(32.4)89
It is impossible for me to achieve good results in the study of genetics.	(8.7)24	(48.2)132	(16.4)45	(26.6)73
I think I excel at genetics	(12.0)33	(19.7)54	(40.8)112	(27.3)75
Many things in genetics are difficult	(9.9)27	(12.4)34	(46.7)128	(31.0)85
It can also solve difficult genetic exercises	(12.4)34	(16.4)45	(41.9)115	(29.1)80
Studying genetics is boring	(60.2)165	(31.0)85	(4.4)12	(4.4)12
We usually have interesting exercises in genetics	(3.6)10	(6.5)18	(64.2)176	(25.5)70
Genetics is one of my favorite subjects in biology	(3.3)9	(8.0)22	(28.4)78	(60.2)165

Attitude and beliefs about genetic determinisms

Their responses showed positive attitudes towards gene technology and acceptance of the use of gene editing (51.4%). Students' perception of the utility of genetics did not differ among them; female and male students had significantly different responses along attitude factors, Female had a more positive perception about the gene editing technologies [X2 (2) = 8.943, p= 0.011]. However liking genetics was the only factor without gender difference. About 74.0% of students belief in genetic determinism and and this was positively correlated with

public high school student which study differnet textbook and course materials (Spearman Correlation ρ=0.348, $p<0.001$). Our study suggests that in general students liked to study genetics and they had mostly favorable attitude towards gene technology (see Table 3).

Regarding the short exam if genes are equated with trait there is no clear distinction between genotype and phenotype, and hence little need to consider a mechanism by which a gene could be expressed in the phenotype. This everyday perspective provided a plausible explanation of the difficulties and misconceptions found.

Table 3. Considerations of attitude and beliefs about genetics

Statement	Number	Frequency
I need knowledge on genetics in my future studies	97	35.5
Genetic knowledge is required skill in everyday life	106	38.6
Understanding genetics is increasingly important	104	37.6
Editing the human genome is ethically acceptable if it allows for the cure of genetic diseases	144	52.7
Genetically modified plants help reduce world hunger	20	7.5
Stem cell research done on human embryos should be illegal	12	4.3
It is acceptable for scientists to develop pathogens by genetic modification if this leads to new cures for diseases	57	20.4
I think genes determine all human traits	144	52
Human intelligence is determined by genes	203	74
	94	34.4

Discussion

Considering that recently in the education system in Albania, some textbooks have been tested in secondary schools and only in recent years a general textbook in the subject of biology has been stabilized, we thought to evaluate how are the perceptions and attitudes of students in genetics. At the same time, with the flow of new information from scientific research in the field of genetics, which has progressed rapidly, the opinion of young people about skills in genetics as an enabling tool for education in general is not known. It is already evident that these findings have not been reflected with the same growth in educational texts, but also in the construction

of the curriculum or extracurricular hours. Before this study, a working group from our institution undertook a national competition with a contemporary theme in genetics. This was not part of our study, but the perceptions in general were that at the secondary level there are large gaps in knowledge and lack of reflection of innovations.

In our study, 274 high school students, from 8 different schools, mainly in Tirana, participated. What prevailed was the liking that young people have for the subject of genetics, listing the need to learn and be skilled in genetics as a necessary skill for the future. Almost 80% found studying genetics interesting (rated agree and strongly agree) and they belief that can excel in genetics. Around 86% of students have knowledge and see genetics as their favorite field in biology. Similar results about the perception of knowledge in genetics reported in several studies (Tornabene et.al., 2020; Aivelo et al., 2021). There were no significant differences in this likability between genders, nor differences between schools.

Reasons behind gender differences are not often discussed in the research of genetics education. As found in many studies gender differences were evident in some factors: male students had more positive attitudes towards gene technology (Mielby et al., 2013; Olofsson et al., 2006; Sturgis et al., 2010) and higher self-concept in learning genetics (Fonseca et al., 2012). In our study male belief in genetic determinism comparing to females, did not find gender differences at all. In general, educational arrangements can affect students' attitudes and beliefs in science education more than gender (Osborne et al., 2003).

Genetic determinism is the belief that genetic contributions to phenotypes are exclusively or at least much more important than the contributions of other factors such as epigenetic and environmental ones, even in the case of complex traits such as behaviors and personality (Mills et.al., 2008; Smith et al., 2010).

52% of participants believe in genetics determinism highlighting that all humans' traits are prone of genes, and 52.7% admitted that editing the human genome is ethically acceptable. 74% of the participants believe in the study of human genomes as a prediction of human diseases, and only 34.4% believes that human intelligence is determined by genes. Those are some confused results to discussed and only a few studies has similar frequencies (Aivelo et al., 2021; Lanie et al. 2004; Mills et.al., 2008), meanwhile they shown lower consideration about genetically modified plants as a solution for sufficiency. It suggests that biotechnology is not well understood. In terms of equating genes to traits, there is no clear distinction between genotype and phenotype, and therefore there is little need to consider a mechanism by which a gene may be expressed in phenotype. This everyday perspective provided a plausible explanation of the difficulties and misunderstandings found (Lewis et al. 2004).

Conclusion

Our study suggests that in general students liked to study genetics and they had mostly favorable attitude

towards gene technology. They are not completely convinced of genetic determinism; this is also made possible by updated books. A complete study combining the textbooks, the knowledge of the teachers, and their approaches are needed.

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