Attitudes of Secondary School Students to Genetic Diagnosis

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Abstract

The aim of this study was to investigate through a questionnaire the attitudes of secondary school students to genetic diagnosis as well as the correlation between them and the students' attitudes to biology or their knowledge of basic genetics concepts. The sample consisted of 617 students of grades 9-12. The students were generally positive towards genetic diagnosis regardless of their gender or age. However, a statistically significant difference was found depending on the direction of studies of 12th grade students. Finally, our research showed a positive correlation between students' attitudes towards biology and their attitudes towards genetic diagnosis as well as a positive relationship between students' genetic knowledge and their attitudes towards genetic diagnosis. The results of the study were used to design and implement a health education program on genetic diagnosis in a junior high school in Greece in order to help the participating students get acquainted with basic genetics concepts as well as the procedures and implications of genetic testing.

Key words: attitudes, genetic diagnosis, health education

Introduction

Objectives

This study investigates students' attitudes towards genetic diagnosis. This research question is a consequence of the emphasis given today on the social dimension of biology, which focuses on students' attitudes towards contemporary issues arising from its spectacular development (Zogza, 2006). Most research on attitudes towards genetic testing concerns adults. Those concerning students either investigate their attitudes generally to genetic testing or compare their attitudes to tests performed for medical reasons with those performed for judicial reasons. This paper is different in that it studies the attitudes of students separately in different types of genetic testing and, thus, it investigates whether the attitudes of students change depending on the type of genetic testing performed. As an extension of this question, it was also studied whether students' attitudes towards genetic testing are influenced by their knowledge, their attitudes towards biology, their gender, their age and their direction of studies. The information and conclusions gained from this study were used for the design and implementation of a health education program entitled "Show me your genes and I will tell you who you are". The program was implemented during the school year 2015-2016 in a public junior high school in Greece in order to engage the participating students in socio-scientific issues involved in genetic testing. Health education programs in Greece are non-compulsory educational programs that take place after school and aim to increase the students' awareness

on a specific health issue. The conclusions drawn from this work could be of use for the improvement of biology curricula.

Theoretical background

It is generally accepted that the applications of genetics and biotechnology, such as genetic testing, genetic engineering, cloning, gene therapy etc., have a significant impact on society and in addition to their advantages they have important moral, legal and social implications. For the evaluation of the above scientifically literate citizens are required (Driver et al., 2000). However, the effective transmission of knowledge regarding the above to the society has encountered several difficulties (Fitzsimmons, 1985) and, although this can be done by the media, it is usually done in an inappropriate way, with a highly dramatic style and prejudice. Therefore, it is important that more emphasis is placed on the teaching of modern genetics in schools, so that adolescents are able to assess the benefits and potential risks posed by the above applications (Santucci et al., 2004). Furthermore, the teaching of modern genetics in schools can benefit society by the transfer of knowledge that students acquire in school to the outside world, especially to the family environment (Santucci et al., 2004).

One of the applications of genetics that receives conflicting reviews regarding its ethical, legal and social implications is genetic testing. Especially after the completion of the mapping of the human genome in 2003 as well as the development of methods for the detection of genetic abnormalities, genetic diagnosis has been a popular topic in both the media and the cinema. However, the society seems to be poorly informed about genetic testing. Consequently, the majority of candidates for genetic testing have little or no knowledge of the basic biological concepts and procedures required to understand the information provided in the process of genetic counseling and the implications involved, a fact that can prevent an autonomous, fully informed decision (Decruyenaere, 1995). Therefore, it is necessary for the students, who are the 'future adults and potential users of genetic tests' (Decruyenaere, 1995), upon graduation from high school, to have the necessary knowledge of basic genetic concepts in order to understand the relationship between genetics and diseases and their prevention or treatment as well as the usefulness of genetic testing. Additionally, they need to acquire critical thinking skills and reflect on the ethical, legal and social issues arising from the implementation of genetic testing, so that as future citizens they can understand articles on the applications of genetics in newspapers and magazines or follow discussions on television, participate in public debates and be able to make informed decisions on whether or not to be tested and in the case they choose to do so to be able to understand the results of the examination and the implications involved.

It is obvious, therefore, from the above that teaching issues of modern genetics is necessary in schools. At the same time, the explosion of knowledge, the pressure to cover an ever-expanding material, the dominance of the internet, which makes knowledge more accessible than ever, the need to connect school knowledge with everyday life and the decrease of young people's interest the Natural Sciences in general, which is mainly the result of the way in which they are taught in school, make the job of the biology teacher extremely important and complex and impose a series of changes in the way biology, and especially genetics, are taught in schools. A significant aid for the teachers in their new role is the focus of academic research on students' interests, goals, perceptions and attitudes towards biology (Mavrikaki et al., 2012) and genetics.

Several studies regarding the attitudes of secondary school students' towards genetic diagnosis have been published. In a study through interviews in Australia among 18 students aged 12-17 most of them were in favor of genetic testing for the detection of genetic diseases in embryos as well as DNA fingerprinting for crime detection and paternity testing (Dawson, 2007). Massarani and de Castro Moreira (2005) in a study of 610 high school students in Brazil showed that there were more students who were in favor of genetic testing for the diagnosis of genetic diseases than those who were positive for genetic testing by insurance companies.

They were also generally negative towards the choice of embryos for aesthetic reasons. Some groups of students mentioned the possibility of a person changing his/her mind about these issues when faced with the obligation of taking a serious decision for his/her own sake. In Greece, a survey of 1,019 12th grade students showed that a large percentage of the sample agreed with the implementation of genetic tests for early diagnosis of genetic diseases, while opinions on the use of genetic tests for justice were generally shared (Yasemis, 2011). Similarly, a survey in Portugal among 698 students aged 17-18 showed that much more than half of the students would undergo a genetic test for medical reasons, whereas less than a half would give the authorities access to their genetic information (Fonseca et al., 2012). In a survey of 132 students aged 17 and 18 in Bulgaria, genetic diagnosis of inherited diseases was regarded as useful by 97.7% of the students, ethically acceptable by 88.1% and dangerous by 21.7%. In contrast, for the test that predicts the talents and the weaknesses of unborn offspring, the corresponding percentages were 42.5%, 28.3% and 57.5% (Kolarova, 2014). In Belgium, a survey by Decruyenaere (1995) found that 17% of the adolescents who took part in the study would certainly seek information about genetic risks before pregnancy and that 39% were likely to do so in order to make informed decisions and be psychologically prepared for the birth of a child with a serious genetic disease. The most common counter-argument was their desire to have children regardless of possible genetic problems. 18% of the students stated that they would like to have a prenatal test and 44% that they would probably do so. The strongest argument against prenatal screening was the reluctance to terminate an established pregnancy. In fact, 16% of the students completely rejected pregnancy termination even in the case of a serious genetic disease. The researchers found no significant correlation between basic genetic knowledge and attitudes toward genetic diagnosis. The research of Zande et al. (2010) is also worth mentioning. The researchers interviewed teachers, genetic tests users, health professionals and bioethicists on the biological concepts as well as the moral, legal and social implications of genetic testing, which they consider important for preparing students as future users of genetic tests. Last but not least, in a study conducted in Leeds among students aged 15-16 on their views and attitudes towards prenatal screening for cystic fibrosis, many students seemed capable of expressing their views with arguments, while those who did not succeed failed due to lack of argumentation and not due to lack of genetic knowledge (Leach et al., 1996).

Method

The questionnaires

According to the Greek biology curriculum students are taught genetics in grades 9, 11 and 12. Hence, the sample consisted of 617 students from 9th to 12th grade from 32 Greek schools (Table 1). There were 3 directions of studies for 12th grade Greek students in the school year the study was conducted (school year 2014-2015). Among the 104 12th grade students of our sample there were 30, 41 and 33 students that attended the 'Science', 'Technology' and 'Humanities' direction respectively.

Table 1. Distribution of the students of the sample by gender and grade

	Boys	Girls	Total
9th grade	90	121	211
10th grade	63	78	141
11th grade	74	87	161
12th grade	42	62	104
Total	**269**	**348**	**617**

For the purposes of the study a questionnaire was constructed by the researchers with an overall cronbach's coefficient of 0.738. The questionnaire included closed-ended questions,

since such a questionnaire could investigate more variables through more questions in comparison to a questionnaire with open-ended questions, which could include less questions for the same duration. Furthermore, with open-ended questions it is difficult to tell whether the lack of accuracy in students' answers is due to their misconceptions or their poor writing skills. Specifically, the questionnaire investigated the students' attitudes towards biology with 8 5-point Likert statements, their knowledge in basic genetics concepts with 37 multiple choice or right-wrong questions and their attitudes to genetic diagnosis with 11 questions either in a 3-point or a 5-point scale (dependent variables).

In the period February-May 2014, the pilot distribution of questionnaires to 40 students was conducted in order to make sure that the students would not encounter any difficulties with understanding and responding to the questions as well as to estimate the time needed for the completion of the questionnaire. After the appropriate changes according to the responses and the comments of the students were made and the necessary document of permission for the distribution of the questionnaire in schools from the Ministry of Education had been obtained, the questionnaires were administered electronically or via post to 60 randomly-picked schools all over Greece in March-April 2015. This period was chosen, so that on the one hand a great part of the material would have been completed and on the other hand the distribution of the questionnaires would not coincide with the in-school and panhellenic exams. In addition, the questionnaire was sent almost simultaneously to all the selected school units, so that all students would have the same experiences from the teaching of the course. 617 questionnaires from 32 schools were returned.

After the questionnaires had been received, the students' responses were coded and introduced to the statistical program IBM SPSSv23. In some cases due to different wording the values were reverted as appropriate. To measure the overall attitude of each student towards biology values 1, 2, 3, 4 and 5 were added for each of the 8 questions and the sum was divided by their number. To measure the overall performance of the students in the part that regarded their knowledge of genetics concepts one point was given for every right answer. These points were added and, hence, a student could have a score between 0 and 37. To measure each student's overall attitude toward genetic testing the following procedure was followed. First, in the questions in which the 5-point Likert scale was used, it was converted to a 3-point one. Then, values 1, 2 and 3 were added for each of the 11 questions and the sum was divided by their number.

To investigate differences among students' knowledge in genetics as well as their views according to the independent variables (gender, grade, direction of studies for 12th grade students) independent samples t-tests, chi-square tests and ANOVA analyses followed by post-hoc analyses were applied as appropriate. A level of significance of 95% was selected. The Pearson r factor was used to correlate students' knowledge in genetics or their attitude to biology with their attitudes to genetic testing.

Here we present only the results regarding the attitudes to genetic diagnosis as well as some of the correlations among the dependent variables of the research.

The health education program

The information and conclusions drawn from the study were used to design a health education program entitled "Show me your genes and I will tell you who you are". The primary goal of the program was the familiarization of the 29 9th grade participating students with basic genetics concepts and their acquaintance with the procedures and the implications of genetic testing, so that, as future citizens, they will be in the position to take a stand towards ethical dilemmas brought over by the advances in biology and medicine and take informed decisions about certain issues. The program took place from December 2015 until May 2016 and included 15 weekly sessions, which are summarized in Table 2.

Table 2. The weekly sessions of the program

Week	Activities
1	Creation of a cooperative working environment
	Division of students in 8 teams
	Formation of a pedagogic contract
	Pre-questionnaire
2	Lab: DNA isolation & Chromosome observation
3-5	Film "GATTACA" & discussion in class
6	Discussion on genetic testing in adults for medical reasons
7	Discussion on prenatal diagnosis, preimplantation diagnosis and choice of characteristics
8	Role-plays
9	Stories-Case studies
10	"The DNA detective game"
11	Teleconference with a representative from the National Bioethics Committee
12	Project assignment in each team
	Searching, processing & editing of material (teams 1-6)
	Creation, distribution & processing of questionnaires (team 7)
	Scenario writing and shooting of short film ("CSI Kozani: Murder in the lab") (team 8)
	"DNA Song" writing & video-clip making (team 8)
	Creation of artifacts for the World DNA Day from single students
13	Participation in the 2nd Health Education Fest
14	Visit to the Department of Biological Applications & Technologies, University of Ioannina, Greece
15	General rehearsal
	Presentation in school event
	Evaluation (Post-questionnaire)

After the completion of the program an evaluation questionnaire was administered to the participating students, which asked the students to rate certain aspects of the program and assessed their views on genetic diagnosis before and after the program as well as their views on whether the program helped them increase their interest in biology, their academic performance, their argumentative abilities etc. Apart from the evaluation questionnaire a short quiz that tested basic genetics knowledge with 19 closed-ended questions was administered to the 29 participating students (experimental group) before the start of the program in December. The questionnaire was also given to the remaining 9th grade students (control group), who would not participate in the program, in order to compare the average score of each group and confirm that the two groups were equal in terms of their knowledge of concepts that would be approached during the program. At the end of the program in May, the questionnaire was given again to both groups in order to compare their scores separately before the start and after the completion of the program. Then, the average scores of both teams were compared in the post-questionnaire. At this point it should be noted that in the intervening period from the start of the program both groups were taught genetics from the biology textbook by the same teacher in the same way.

To measure the overall performance of the students in the short quiz the students' responses on each of the 19 questions were coded and introduced to the statistical program IBM SPSSv23. Specifically, one point was given for every right answer. These points were added and, hence, a student could have a score between 0 and 19. To investigate differences between the ecperimental and thw control group before the start and after the completion of the program independent samples t-tests were applied. A level of significance of 95% was selected.

Results

The questionnaires

Only 20% of the students agreed to the creation of a national database with the DNA of every citizen of the country. A little less than half of the students (47.5%) would choose to be tested in order to find out about all the genetic diseases from which they could possibly suffer in the future, while 9.1% would only like to know about some of them. The rest of them were either not certain (28.5%) or responded that they would not like to know (14.1%). From those who answered that they would be examined either for all the diseases or for some of them, 56% agreed that the examination would give them the possibility of diagnosis and therapy of a genetic disease, 59.8% that it would give them the possibility of prevention of a genetic disease, 46.7% that it would assist them to prepare psychologically and 41.4% that it would give them the possibility to program their lives. From those who were skeptical or negative towards genetic diagnosis 30.9% were concerned about access to their genetic information, 21.3% were thinking about possible stigmatization following notification of the result to third parties, 24.6% were thinking about possible discrimination regarding employment or insurance, 24.7% were not convinced about the reliability of the test, 16% had religious or moral objections, 37.3% and 30.8% were wondering whether the test result would influence their personal choices or lead them to extreme reactions respectively and 24.7% were concerned about the fate of the DNA sample after the test.

As far as prenatal diagnosis is concerned, it seems that the students of the sample regarded that the importance of prenatal screening lies to the fact that it gives the couple the opportunity to prepare psychologically for the birth of an unhealthy child, since 51% of the students agreed with this statement. 44.4% found it important, as it enables planning of the delivery of the newborn child and 39.9% because it reduces the anxiety of future parents. Fewer agreed to the performance of prenatal screening with the aim of terminating the pregnancy of an unhealthy fetus or preparing financially for the birth of an unhealthy child.

As to preimplantation diagnosis 47.7%, 49.9% and 30% agreed with its implementation for diseases that lead to death before the age of 2 years, at the age of 10-20 years and at the age of more than 50 years respectively. 50.5% agreed with the preimplantation diagnosis of Down syndrome and 40.4% with its use for the birth of a child compatible with a sibling who suffers from a severe hereditary anemia so that the bone marrow can be used. Fewer agreed with its use for gender selection or selection of characteristics (16.1% and 18.5% respectively).

The comparison of the overall score of students' attitudes towards genetic diagnosis according to gender or grade did not show any statistically significant differences ($t = -1.198$, $df = 502.573$, $p = 0.232 > 0.05$ and $F = 0.130$, $df = 3$, $p = 0.942 > 0.05$ respectively). However, the comparison of the total score of the attitudes of the 12th grade students towards genetic diagnosis according to their direction of studies showed a statistically significant difference between the students of the 'Science' and the 'Technology' direction ($F = 5.634$, $df = 2$, $p = 0.005 < 0.01$), with the students of the 'Science' direction being more positive.

Interestingly, 74.5% of the students would like to learn more at school about genetic diagnosis. This response was influenced by gender, as more girls responded positively ($\chi^2 = 12.218$, $df = 1$, $p = 0.00 < 0.001$), as well as grade ($F = 6.598$, $df = 3$), since more 11th ($p = 0.00 < 0.001$) or 12th grade students ($p = 0.007<0.01$) than 9th grade ones would like to know more about genetic diagnosis at school. On the contrary, the direction of studies did not influence responses to this question ($F = 0.998$, $df = 2$, $p = 0.372 > 0.05$).

Finally, in our research a positive relationship between students' attitudes towards biology (mean = 3.4160, SD = 0.76789) and their attitudes towards genetic diagnosis (mean = 2.1422, SD = 0.32914) was found ($r = 0.182$, $p = 0.00 < 0,001$) (Figure 1). Moreover, we found a positive correlation ($r = 0.121$, $p = 0.004 < 0.005$) between students' genetic knowledge (mean = 17.4797, SD = 6.87976) and their attitudes towards genetic diagnosis (mean = 2.1422, SD = 0.32914) (Figure 2).

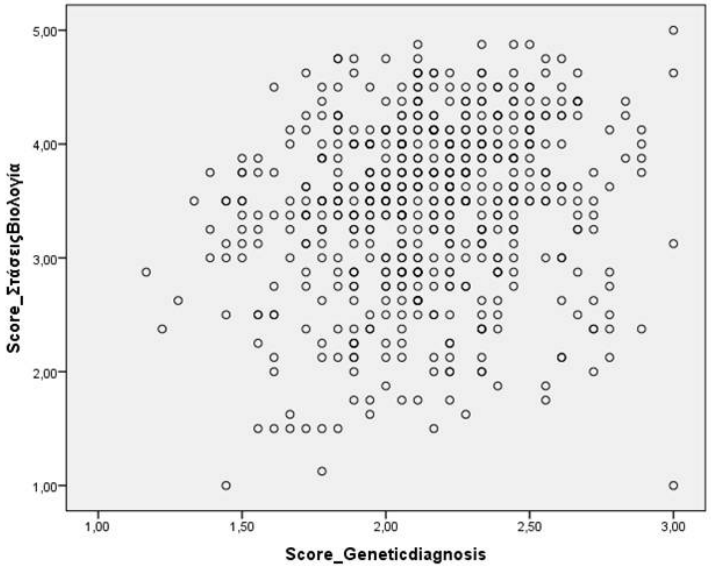

Figure 1. Relationship between students' attitudes towards biology and their attitudes towards genetic diagnosis

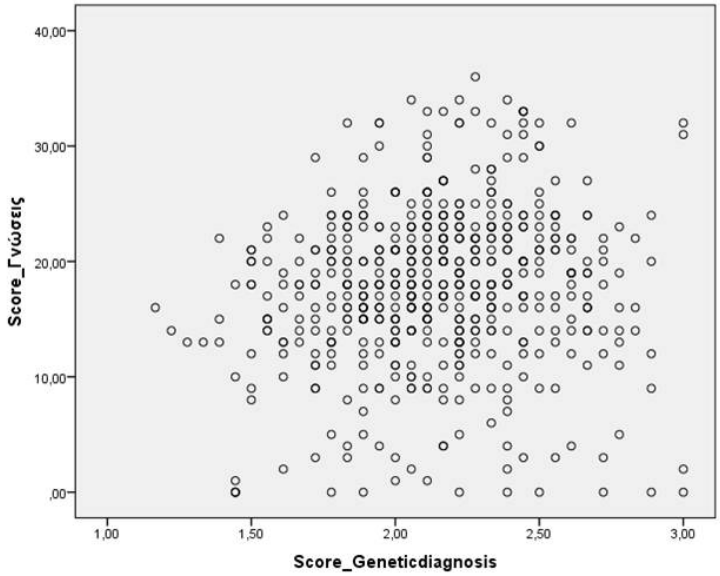

Figure 2. Relationship between students' attitudes towards biology and their attitudes towards genetic diagnosis

The health education program

Table 3 shows the frequencies and the percentages of students that rated certain statements of the questionnaire with 4 ("I agree") or 5 ("I totally agree"). We observe that the students as a whole stated that the program helped them understand how DNA relates to everyday life and that they would re-participate in a program of similar thematology. In addition, the majority of the students stated that their interest in biology was increased and that their academic performance as well as their ability to support their views with arguments were improved due to their participation in the program.

Table 3. Statistics of students that rated certain statements of the questionnaire with 4 ("I agree") or 5 ("I totally agree")

Statement	N	Frequencies	Percentage %	Av.*	SD*	Min	Max
I would participate in a program of similar thematology again.	29	29	100	4,79	0,41	4	5
The program helped me understand how DNA connects to everyday life.	29	27	93,1	4,48	0,63	3	5
My interest in biology was increased.	29	25	86,2	4,48	0,83	2	5
My academic performance in biology was improved.	29	25	86,2	4,17	0,89	1	5
My ability to support my views with arguments was improved.	29	25	86,2	4,28	0,7	3	5

*Av. = Average, SD = Standard Deviation

Furthermore, four of the participants stated that they knew what genetic diagnosis was before the start of the program and this number was increased to 26 students with the completion of the program. Of those who responded that they knew what a genetic diagnosis was in December, one responded that he/she was in favor of genetic diagnosis and three that they were in favor or against, depending on the type of diagnosis. After the completion of the program out of the 29 students who completed the program 6 were in favor of genetic diagnosis (20.7%), 17 in favor or against according to the type of diagnosis (62.1%) and 6 did not answer this question.

Table 4 shows the average performances of the students (experimental and control groups) in the quiz. The average performance of the control group in December was 11.04 and that of the experimental group 11.52. The t-test showed that there was no statistically significant difference between them ($t = -0.794$, $df = 94$, $p = 0.429 > 0,05$), so we conclude that the two groups were generally at the same level of knowledge before the start of the program. In May, the average performance of the control group was 13.65 and that of the experimental group 15.26. It seems that in both groups there was an increase in their score between December and May. This difference was statistically significant in both the control group ($t = -5,189$, $df = 127$, $p = 0.00 > 0.001$) and the experimental group ($t = -5,019$, $df = 52$, $p = 0.00 > 0.001$). We believe that this increase in the control group was a result of the teaching of the unit of genetics, while the corresponding rise in the experimental group was due to the combination of teaching and participation in the program. The increase was higher in the experimental group (average score = 15.26) compared to the control group (average score = 13.65) and the t-test showed that this difference was statistically significant ($t = -2,315$, $df = 85$, $p = 0.023 < p = 0.05$).

Table 4. Average performances of the experimental and the control group in the quiz before the start of the program and after its completion

	Experimental group			Control group		
	N	Av.	SD	N	Av.	SD
Pre-questionnaire	27	11,52	2,887	69	11,04	2,535
Post-questionnaire	27	15,26	2,581	60	13,65	3,167

*Av. = Average score, SD = Standard Deviation

Conclusions

In general, it seems that the students of our sample were positive towards genetic diagnosis, with the exception of the creation of a national database containing DNA from every citizen of the country, the performance of prenatal testing in order to terminate the pregnancy of an unhealthy fetus or to financially prepare for the birth of an unhealthy child and the performance of preimplantation diagnosis for gender selection or selection of traits as well as for genetic diseases that lead to death at the age of more than 50 years.

Comparing the overall score of students' attitudes towards genetic diagnosis depending on their gender or grade did not show a statistically significant difference. In contrast, the comparison of this score among 12th grade students depending on their direction of studies showed a statistically significant difference between the students of the 'Science' direction and those of the 'Technology' direction, with the students of the 'Science' direction being more positive.

Additionally, our research showed a positive correlation between students' attitudes towards biology and their attitudes towards genetic diagnosis. Moreover, it showed a positive relationship between students' genetic knowledge and their attitudes towards genetic diagnosis, in contrast to a research in Belgium in which no significant correlation was found (Decruyenaere, 1995). Our results agree with the results of the Eurobarometers 55.2 and 58.0, according to which the attitudes of the participants towards science and technology in general and genetic diagnosis of genetic diseases in particular were more positive among those with more knowledge of biotechnology (European Commission 2001; Gaskell et al., 2003).

Interestingly, the majority of the students who participated in the study replied that they would be interested in learning more about genetic diagnosis at school and this should be taken into account when revising the content of the school subject of biology.

The results of the study were used to design a health education program which was implemented with 29 9th grade students in a public junior high school in Greece. It is worth mentioning that the textbook used for biology teaching in grade 9 in Greece includes amongst others a chapter on genetics, through which the students are taught basic genetics concepts, such as DNA, genes and alleles, chromosomes, DNA replication, gene expression, cell division, mendel's laws and mutations. Hence, a program like the one we implemented offers the biology teacher the possibility to approach concepts that are not included in the school textbook, such as modes of inheritance, genetic diagnosis etc. Moreover, since 9th grade students in the greek education system are unfortunately taught biology only once a week, such a program, apart from helping the students to improve their argumentative ability and understand how DNA relates to everyday life, it could also help them to deepen their genetics knowledge and, therefore, increase their academic performance, as suggested by the performance of the experimental group to the quiz as opposed to the control group.

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