Student-scientist collaboration in the global learning and observations to benefit the environment program

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ABSTRACT

The study aims to determine how one-year collaboration experience on a research project affects the recognition of collaboration benefits and the development of a student's interest in science. 141 students did research projects in 33 collaborative groups with two scientists within the global learning and observations to benefit the environment (GLOBE) program, after which they filled out the 5-point Likert-scale questionnaire. Results show no significant difference in student attitudes about collaboration between gender and educational level. Extremely affirmative students think that important things about collaboration are: the positive influence on their knowledge, improving project writing skills, gaining self-confidence, and growth of the quality of the project. Students who appreciate scientists recognize that they achieve a better understanding by collaborating with them. Students have positive attitudes about future work in the field of science, especially older students. It was established that developing research projects with scientists affects students' choice of a scientific career. Students who feel under stress, think that they achieve less understanding during the research process. Boys are focused on the negative aspects of collaboration, while girls are more focused on collaboration's effects on their knowledge. Future studies can investigate if interest in science remains over the years, the effect of collaboration on scientific literacy and expanding basic knowledge.

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1. INTRODUCTION

For decades scientists and teachers have been looking for ways how to interest students in science [1], [2], because it has been identified as crucial in making decisions about science careers [3], [4]. Researches provide evidence of how inquiry teaching [5], [6], and engaging students in learning experiences that enable them to interact with scientists [4], [7], [8], affect students' interest in science. So, in the last decades, many educational programs and summer camps have enabled students to get to know scientists and to work with them e.g.: biotech in action (BIA) [9], Vattenhallen Science Center [10], students at the university [11]. Still, the Organization for Economic Co-operation and Development (OECD) expresses the rising need for workers trained for careers in science, technology, engineering, and mathematics (STEM) areas in the whole world [12]. We were wondering why there are so many arguments about fostering student interest, but yet a need for students who are interested in STEM? the answer could be in the duration of educational programs in which students participate. Some research show that short-term engagement of students in such activities also has a short-term effect on students' interest [13], [14].

We wanted to get insight into students' attitudes about science and careers in science after engaging in a program that enables them to interact with scientists on projects that last for one school year. The program that enables such a unique experience is the global learning and observations to benefit the environment (GLOBE) program. It is an international scientific-educational program. Students through The GLOBE program are doing regular and continuous measurements and observations in the immediate environment of the school [15]. By practicing GLOBE, students have a practical approach to the scientific method, acquire new knowledge about the integrity of the environment, and develop positive attitudes about science and self-awareness based on their active contribution [15]. Scientists provide schools with professional guidance in the study and measurement of the environment, equipment and a sense of importance, and in return, they receive a large amount of data for their research [16]. The value of the program stems from the fact that it represents a worldwide community of students, teachers, scientists, and citizens who work together to better understand, maintain and improve the earth's environment at the local, regional and global levels [17]. The great success of the GLOBE program in Croatia was contributed by the Croatian GLOBE Student Conference and Competition, where highly motivated students, from all over Croatia, present projects they did with the help of scientists during one school year, with great attention paid to scientific writing [15].

There have been studies about the GLOBE program and its effect on students' satisfaction with science education [18], inquiry competence [19], and choosing a career in science [20]. Previous studies investigated the effect of students participating in short-term educational programs inquiry learning by GLOBE protocol [9]–[11] or big worldwide campaigns led by scientists as part of the GLOBE program [18]–[20]. Our research brings a more intimate view of student-scientist collaboration in the GLOBE program, where a group of three students collaborated with two scientists on a research project designed by students. Students connect their results with the data available on the GLOBE platform collected by students from all over the world through the same protocols, in research interpretation.

This study contributes to understanding students' attitudes about the benefits of intensive collaboration with scientists. It also reveals what it is in collaboration that encourages students to choose Science carrier. Study contributes to the literature on ways to support the implementation of inquiry learning in schools and students' wishes about teacher role in collaboration with scientists.

2. METHOD

The study aims to evaluate and highlight the GLOBE program as a platform for student-scientist collaboration. We wanted to get an insight into student attitudes about science and careers in science after a research project of students and scientists with a group collaboration. Based on the aim of the study, the following hypotheses were set: i) collaboration experience affects the recognition of collaboration benefits and the development of students' interest in science; ii) developing research projects with scientists affects students' choice of a scientific career; and iii) there is no significant difference in student attitudes towards collaboration with scientists between gender and educational level.

Participants in this reflective study were 141 students (52 boys and 89 girls) who participated in the Croatian GLOBE Student Conference and Competition, of which 93 elementary school (E) students (aged 10 to 13) and 48 high school (H) students (aged 14 to 17). The ratio of elementary and high schools (60:40) in the Croatian GLOBE program, as well as the proportion of boys and girls, corresponds to the population that participates in the Croatian GLOBE Student Conference and Competition every year [15]. Students who participated in the GLOBE Student Conference and Competition were selected based on their engagement in the GLOBE program at the regional level, so the sample is considered convenient and representative [15]. Students in a group of three (39 groups), created and presented research projects based on data collected during work within the GLOBE program, with the support of two scientists who were their mentors during the research. Projects were interdisciplinary and included collaboration with scientists from the fields of hydrology (seven projects), pedology (six projects), physics (seven projects), meteorology (seven projects), botany (five projects), and chemistry (seven projects).

After the research paper presentation and conversation with professional scientific judges, students filled out a questionnaire, as in Table 1 regarding their attitudes towards collaboration with scientists. A 5-point Likert scale was used to determine student attitudes about collaboration between students and scientists so that the GLOBE program, could be evaluated and improved, where 1 indicates the attitude-I do not agree at all, and 5-I completely agree. The questionnaire was created using the online tool Google Forms and consists of 3 generalized questions (gender, education level, school) and 33 specific items related to the creation of the project during the collaboration with the scientists and participation in the competition of the created projects and (A4-A36). The questionnaire was valid for analysis and showed high reliability and good consistency (Cronbach Alpha=0.873). During the interpretation item mean, the answers were classified as positive (>3.6), neutral (2.5-3.5) and negative (<2.4). Collaboration was done in a group of three students (39 groups) and two scientists per group over one year. They worked together on a project students designed based on collected environmental measurement data. Exploratory factor analysis (EFA) of specific questions as in Table 1 made it possible to isolate the components described as the most significant characteristics that influence students' successful participation in projects during collaboration with scientists.

Table 1. Descriptive statistics and communalities of items

	Extraction method: principal component analysis	Mean	SD	Communalities
A5	Questions that scientists have asked me were tough.	2.12	0.982	0.681
A6	When I was presenting my research. the atmosphere was nice.	3.99	1.049	0.807
A7	The communication with the scientists was serious and formal.	3.84	0.973	0.623
A8	The questions were clear.	4.25	0.904	0.745
A9	Presenting in front of scientists and students is stressful.	3.46	1.192	0.695
A10	Presenting helped me gain confidence and made me lose performance anxiety.	3.99	1.052	0.691
A11	I was proud of myself when I answered the questions asked by scientists.	4.30	0.954	0.688
A12	I think my project has gained in importance due to the evaluation of the scientists.	4.10	0.920	0.725
A13	I gained a positive opinion of the scientists based on talking to them.	4.28	0.838	0.672
A14	I felt frightened and insecure when talking to scientists.	2.74	1.227	0.653
A15	Due to the criticism of scientists. I no longer want to do research.	1.60	0.940	0.547
A16	During scientific research scientists talked mostly with my teacher not me.	3.60	1.183	0.661
A17	During scientific research scientists talked to me and gave me some great advice on how to make research better.	3.92	1.029	0.477
A18	We communicated mostly via e mail with scientists.	3.65	1.220	0.701
A19	I would love to have more contact with scientists while researching.	4.01	0.989	0.775
A20	From the communication with the scientists. I learnt about the process of investigation and research.	4.08	1.015	0.780
A21	During communication with scientists. I learnt more about science topics that I was researching.	3.91	1.045	0.777
A22	During the communication with the scientists. I learnt more about the science topics that other students were researching.	4.30	0.892	0.697
A23	The collaboration with the scientists should be part of a regular class.	4.01	1.042	0.747
A24	Talking to scientists made me feel like a part of a scientific club.	4.13	0.861	0.684
A25	Scientists made me think critically about my research.	3.90	0.913	0.756
A26	While investigating and talking to scientists I have learnt to think in a scientific way.	4.08	0.837	0.741
A27	I gained a better insight into the work of a scientist.	4.04	0.967	0.750
A28	The scientist encouraged me to do new research.	4.45	0.741	0.750
A29	Investigations are interesting and should be part of a regular class.	4.18	0.872	0.720
A30	The criticism of the scientists was useful to me and encouraged me to be better at writing projects.	4.08	0.926	0.675
A31	Project writing is an extensive and demanding process but could be carried out on a smaller scale and in regular classes.	3.62	1.296	0.913
A32	In addition to creating the project. I learned a lot about the scientific areas related to my research.	3.82	1.191	0.823
A33	Creating a project helped me understand the content that was not completely clear to me during the class.	4.19	1.062	0.693
A34	One day I want to become a scientist.	3.55	1.273	0.907
A35	The investigation is easier to do with the help of scientists.	4.08	0.979	0.657
A36	The collaboration with the scientists makes me feel important.	4.30	0.726	0.597

Preliminary analysis showed that all statements had loading scores greater than 0.4 in at least one factor. Only the statement *"Scientists should not be judging students' reports"* (A4) did not meet this condition in any factor, so it was dropped from further analyzes. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy with a value of 0.804 indicates that the degree of information among the variables overlaps greatly with a strong partial correlation. A significant statistical Bartlett's test of sphericity ($p<0.005$) shows that the correlation matrix is indeed not an identity matrix. Hence, it is plausible to conduct factor analysis with meritorious interpretation [21].

The communality values are generally high for all the variables as in Table 1, which indicates that variables are well represented by the factors. The ten components and their respective items that were obtained from the EFA procedure are presented in Table 2. Items with a factor loading greater than 0.3 were used when defining the factors, because it indicates a moderate correlation between the item and the factor [22]. The extraction method of principal component analysis (PCA) with variation maximization or VariMax rotation was implemented on the 32 items through 22 rotation iterations. All ten factors together explain the 71.3% variability in the data. For further analysis, factor score coefficients are used with Bartlett's approach, where only the common factors have an impact on factor scores and unique factors across the set of variables are minimized, resulting in factor scores being highly correlated to their corresponding factor and not with other factors [23]. The tenth factor includes only one item *"During scientific research scientists talked mostly with my teacher, not me"*

(A16) so it was excluded from further analyses. The internal reliability specifies a particular set of items' effectiveness levels in measuring the respective factor component for items with factor scores >0.4 and the highest value of factor scores, as in Table 2. The threshold value of Cronbach's Alpha for the items to achieve internal reliability must be greater than 0.7, so factors 4, 6, 8 and 9 were excluded from further analysis. For further study, factors 1, 2, 3, 5 and 7 can be used due to the good internal connection of the items.

The students' answers were tested with the Shapiro-Wilk test, which indicated that the data was not normally distributed ($p<0.05$). Due to the absence of a normal distribution of data and due to small samples of unequal size concerning the level of education of the students, non-parametric tests were applied in the data analysis. The Kruskal-Wallis test was used due to the limited number of participants and unequal age distribution (which we could not influence) to determine the difference according to the level of education and gender of the students, within the statements extracted as a basis for the analysis of the results according to the research questions. Selected questions related to students' collaboration experience with scientists and their recognition of collaboration benefits were used to determine the influence of collaboration on interest in science with the application of the Mann-Whitney U test on the biology achievement in respiration test (BART) factor score (factor scores coefficient with Bartlett's approach) for analysis of well-connected factors 1, 2, 3, 5 and 7. To determine the differences in students' collaboration experience with scientists, students were divided into groups of highly affirmative (Likert scale answers 4 and 5) and less interested/motivated (Likert scale answers 1, 2 and 3).

Table 2. Factor score coefficients, reliability measures for items in factors and total variance explained with rotation sums of squared loading

Item/component	Corrected item-total correlation	Cronbach's Alpha if item deleted	1. The importance of collaboration with scientists	2. Willingness to learn and explore	3. Student insecurity and stress	4. The communication impact on students'	5. Positive attitude towards scientists	6. Scientific consciousness	7. Satisfaction during competition communication	8. Students personal development	9. Contributes to students' understanding	10. Negative experiences in collaboration with
A21	0.71	0.88	0.82									
A20	0.75	0.88	0.77									
A27	0.70	0.88	0.76									
A19	0.73	0.88	0.73			0.37						
A23	0.71	0.88	0.68					0.35				
A13	0.67	0.89	0.67							0.30		
A29	0.55	0.89	0.57		-0.34		0.35					
A26	0.58	0.89	0.52	0.43								
A35	0.56	0.89	0.49					0.32			0.39	
A34	0.82	0.58		0.92								
A31	0.82	0.58		0.92								
A17	0.43	0.96		0.43								
A5	0.47	0.68			0.77							
A14	0.55	0.57			0.76							
A9	0.56	0.57			0.72							
A32	0.52	0.51				0.77					0.30	
A18	0.47	0.55				0.66		0.38				
A7	0.39	0.61				0.58						
A36	0.38	0.63				0.45	0.31					
A28	0.64	0.45					0.77					
A30	0.38	0.76					0.66					
A22	0.52	0.57		0.38			0.65					
A25	0.46		0.36					0.73				
A24	0.46							0.55	0.34			
A6	0.61								0.83			
A8	0.61		0.32						0.75			
A11	0.46	0.64								0.76		
A12	0.60	0.47	0.55							0.56		
A10	0.45	0.66						0.46		0.53		
A33	-0.07										0.65	
A15	-0.07										-0.64	
A16												0.75
Cronbach's Alpha			0.90	0.82	0.70	0.65	0.70	0.63	0.76	0.68		
% of variance			16.01	8.44	7.21	6.78	6.72	6.00	5.99	5.62	4.37	4.13
cumulative %			16.01	24.45	31.67	38.45	45.17	51.17	57.15	62.77	67.14	71.28

Extraction method: principal component analysis, rotation method: Varimax with Kaiser normalization, rotation converged in 22 iterations.

Hierarchical clusters along with the Euclidian distance measure and the median linkage clustering method was used to determine the interrelationship of students' opinions and extract the most significant factors that can be observed during the collaboration of students and scientists in the creation of student research and their choice of a scientific career. The median linkage method combines two clusters with equal weight in the centroid calculation, regardless of the number of cases, allowing small groups to have an equal effect on the characterization of larger clusters into which they are merged. At the same time, students' opinions are connected in cluster groups named according to the features of the questions included in the cluster, to single out an influencing cluster. Decision tree (growing method chi-squared automatic interaction detection (CHAID); alphasplit=0.05; alphamerge=0.05 adjust=Bonferroni) was applied to determine the most important connection between the opinion that scientists encouraged students to do new research. Each pair of predictor categories is evaluated to determine which is least significantly different from the dependent variable, and because of these pooling steps, a Bonferroni-adjusted p-value is calculated [24]. We need to emphasize that the results of the study relate just to those students who participated in the Croatian GLOBE Student Conference and Competition. Results cannot be generalized to the whole population of GLOBE students. All statistical analyzes were made with the SPSS software package [25].

3. RESULTS AND DISCUSSION

Students accept scientists' assessments well of research projects (A4), with only 7.8% of students being against them. According to the mean values as in Table 1, almost all students' answers are positive. The only negative values are related to statements with a negative connotation. The A5 *"Questions that scientists have asked me were tough"* and A15 *"Due to the criticism of scientists, I no longer want to do research"*, these are also positive answers. Neutral responses were observed only with statements A9 *"Presenting in front of scientists and students is stressful"* and A14 *"I felt frightened and insecure when talking to scientists"* as in Table 1. Based on such results, it can be concluded that students have a positive attitude about collaboration with scientists. The criticisms of scientists did not discourage students from doing research as in Table 1. Negative experiences in collaboration with scientists as in Table 2 are mostly because their teachers in most cases (58.9% of students agree) took over the communication with the scientist during the creation of the project (A16). Many other studies also show positive impact of student-scientist collaboration on students' attitude about scientists and science [9]–[11]. Students mostly agree that they would like more direct contact with scientists and that it would be good if such collaborations and research could be part of regular classes. Also, they mostly agree on how they learned about the research process and scientific concepts regarding regular class and other students research. Studies show that the GLOBE program is implemented in regular classes only with a small group of students and even 50% of teachers say they have difficulties implementing the GLOBE program in the school curriculum [26]. In contrast, research on the utilization of GLOBE protocols in teaching [27] has shown that these protocols can be effectively integrated into the curricula of regular subjects, and teachers have successfully utilized GLOBE environmental measurement protocols in standard science classes.

To determine the differences in students' collaboration experience with scientists, students were divided into groups of highly affirmative and less interested/motivated. Most differences were observed in the categories transition between the answers-I mostly disagree-I neither agree nor disagree-I mostly agree-as in Table 3 (see in appendix). Claim A13 *"I gained a positive opinion of the scientists based on talking to them"* stands out from the others because of the established significant differences between all pairs of responses as in Table 3, due to the linear students' responses growth towards the higher agreement, which is not present in other claims.

The opinion of whether research is easier to carry out with the support of scientists (A35) was used to analyze affirmative opinions about collaboration with scientists against negative and neutral opinions. Extremely affirmative students point out the positive influence on science knowledge (A33 $\chi^2_{(df\ 1)}$=19.334; p<0.001) and research knowledge (A22 $\chi^2_{(df\ 1)}$=11.105; p<0.01), as important. The positive attitude towards scientists is related to the feeling that they have improved project writing skills (A30 $\chi^2_{(df\ 1)}$=6.571; p<0.05) and gained self-confidence (A10 $\chi^2_{(df\ 1)}$=4.561; p<0.05). Also, an important determinant of a positive student attitude towards scientists was the opinion about the growth of the quality (A17 $\chi^2_{(df\ 1)}$=6.560; p<0.05) and importance (A12 $\chi^2_{(df\ 1)}$=6.980; p<0.01) of the project. Many studies agree with our findings showing how collaboration with scientists positively affect students self-confidence and interest in science [9], and science and research knowledge [18], [19], [27]. Study of author Cincera and Maskova [28] showed that practicing the GLOBE program does not affect research skills. Such results can be partially attributed to differences in program implementation and insufficient support for teachers in program implementation. Some participants of the GLOBE program are focused on data collection, while others are dedicated to research work [28].

EFA of specific questions as in Table 2 isolates five components described as the most significant characteristics that influence students' successful participation in projects during collaboration with scientists. The importance of collaboration with scientists (F1) includes most statements, with positive answers ranging from 73% to 82.3%. The students mostly agreed that they gained a positive opinion of the scientists based on talking to them (A13), that scientists encouraged them to think critically about research (A25) and that they gained a better insight into the work of a scientist (A27). Willingness to learn and explore (F2) is characterized by awareness that scientists advised on how to make research better (A17, 61.8% of positive opinions). Positive attitude towards scientists (F5) is described by the encouragement for new research (A28, 87.9% positive answers) and sense of importance (A36, 84.4% positive answers). For satisfaction with communication during competition (F7), the most important thing is that questions were clear (81.6% positive answers). Student insecurity and stress (F3) includes presenting in front of scientists and students (A9, 48.2% of positive responses). Mann-Whitney U test BART factor was carried out with grouping variable A33 *"Creating a project helped me understand the content that was not completely clear to me during the class"* comparing students according to highly affirmative answers shows significant differences in three factors. The 62% of students point out (U_{F3}=1002; p<0.005) student insecurity and stress, which indicates that students under stress achieve less understanding and are less able to connect new knowledge during the research process, with related contents that are studied as part of regular classes. The influence of F1 the importance of collaboration with scientists (U_{F5}=1142; p<0.05) and F5 positive attitude towards scientists (U_{F1}=1259; p<0.05) emphasizes that students who appreciate scientists and notice the importance of collaboration recognize that during this collaboration they achieve a better understanding. Similar results showed study [27], where it was concluded that it was the collaboration with scientists that contributed to the students feeling like part of the scientific community and study [19] where it was concluded that students believe that their research is important because it contributes to a better understanding of the environment. Students point out scientific and professional development as a collaboration advantage see in Figure 1.

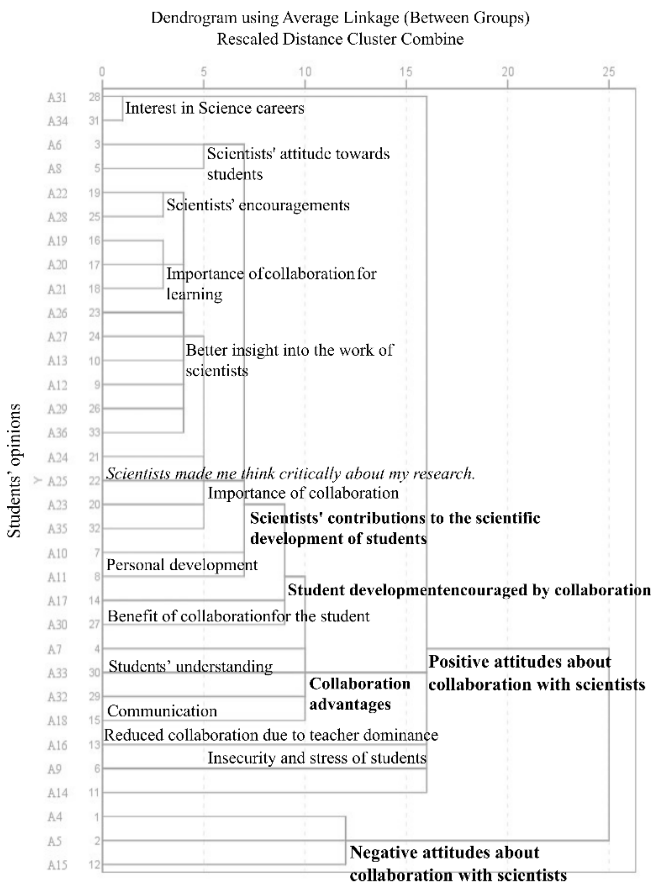

Figure 1. Dendrogram of students' opinions based on answers to the claims of the survey questionnaire (A4–A36) using median linkage (rescaled distance cluster combine)

A dendrogram using the median language method as in Figure 1 contrasts a small part of students' negative attitudes about collaboration with scientists (largest distance coefficient 412.396) with the majority of positive attitudes about collaboration with scientists. A fairly homogenous cluster (smallest distance coefficient 40.000) within the branch of positive attitudes are students who express interest in science careers. Statement

A25 *"Scientists made me think critically about my research"* is the median of the expressed opinions as in Figure 1, and it was used as the basis for further connection and the views that highlight the cluster importance of collaboration with scientists. Students perceive collaboration advantages based upon clasters scientists' contributions to the scientific development of students and student development encouraged by collaboration, which influences the positive opinion of students about collaboration with scientists, as in Figure 1. Similar results showed by Zhang *et al*. [9] where high school students that took part in week-long online biotechnology program felt they developed in scientific and professional way and they showed better understanding of biotechnology field and interest in science career.

The statement A28 the scientist encouraged me to do new research, achieved the highest mean value of student answers (M=4.45, SD=0.741) and was used as a dependent variable for the application of the CHAID decision tree (alphasplit=0.05; alphamerge=0.05 adjust=Bonferroni). In this way, students' interest in future work, in STEM (A34 $\chi^2_{(df\ 1)}$=12.482; p<0.005), was the most significant factor regarding students' interest in conducting new research, as in Figure 2.

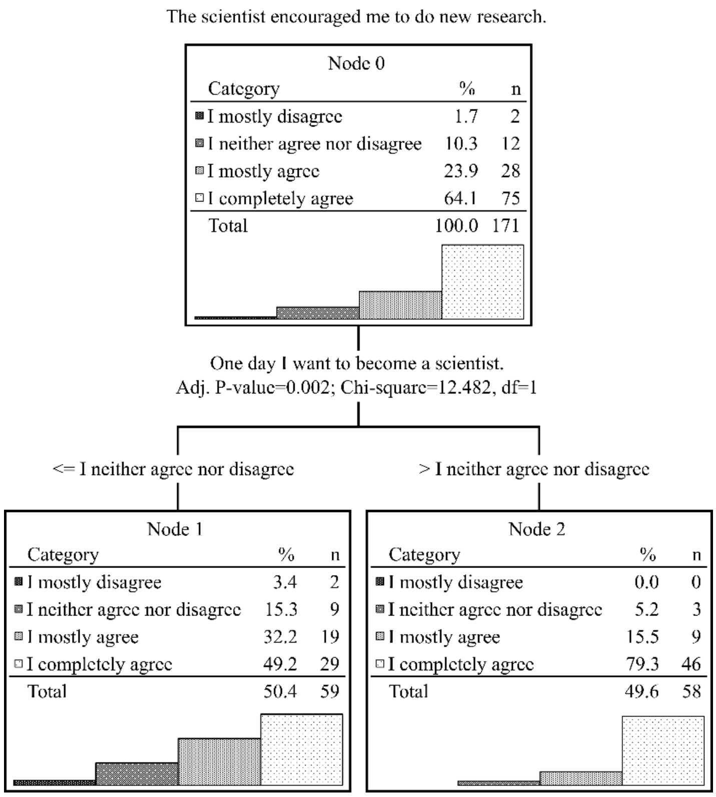

Figure 2. Classification tree for all statements of the questionnaire (growing method CHAID; alphasplit=0.05; alphamerge=0.05 adjust=Bonferroni; dependent variable: *the scientist encouraged me to do new research*)

The root node was also a terminal, containing all students split into two child nodes, one containing student's that are not interested in future scientific work and the other who want to work in the STEM field as in Figure 2. The 79.3% of students, who think that scientists encouraged them to do new research, want to become scientists in the field of natural sciences as in Figure 2. It is noticeable that a higher percentage of high school students (61.54%) agree that one day they want to be scientists in the field of natural sciences than elementary school students (51.28%). The risk as a proportion of cases misclassified by the proposed classification is 0.359 (SE=0.044). The model classified 100% of students who want to be scientists correctly.

In accordance with the described results of this research, the research Winklerova *et al*. [20] also showed that participation in the GLOBE program influenced the choice of a professional career for many GLOBE students. It is noticeable that a higher percentage of high school students agree that one day they want to be scientists in the field of natural sciences than elementary school students. The result points to how student interest in a career in science can be maintained and even increased over the years, among other things, by directly involving students in research. Numerous studies show the exact opposite [13]. In research Ozogul *et al*. [14] students showed an interest in doing science, but this interest decreases with time and age.

Such results highlight the even greater importance of the GLOBE program, where there is a long-term form of collaboration of several months or even several years [15].

The Kruskal-Wallis test did not determine the existence of differences between the factors about the gender of the students. Despite this, boys are more inclined to think that scientists ask difficult questions (A5 $\chi^2_{(df\ 1)}$=4.267; $p<0.05$) and that research presentation is stressful (A9 $\chi^2_{(df\ 1)}$=6.290; $p<0.05$). In contrast to such a different opinion focused on the negative aspects of collaboration, girls are more focused on the effects of student-scientist collaboration. Thus, compared to boys, girls value more the contribution of collaboration with scientists when expanding knowledge on the topic of their research (A21 $\chi^2_{(df\ 1)}$=6.474; $p<0.05$). They agree that research should be part of regular classes (A29 $\chi^2_{(df\ 1)}$=8.207; $p<0.005$) and that they have clarified the parts that were not completely clear to them during the previous study (A33 $\chi^2_{(df\ 1)}$=3.686; $p<0.05$).

Numerous studies show that girls show less interest in science [29] which may be a reflection of social stereotypes, peer influence, stereotypes about scientists [30] and the biases of their teachers who are more inclined to praise boys [31]. However, more girls than boys participate in the GLOBE program in Croatia, which shows that they are more interested in science research. This can be a result of the greater number of female teachers who lead the GLOBE program in Croatia, as well as the greater representation of female scientists who collaborate with GLOBE schools [15]. Teachers represent role models for young girls and thus encourage them to engage in science [9]. Although most studies talk about the dominance of the male gender in science, this is equalizing over time, especially in the fields of biology and chemistry [32] which are widely represented in the GLOBE program [15].

To analyze students' attitudes about scientists and their perception of themselves during collaboration with scientists, students' answers were grouped according to their level of education. The only established difference is according to age in the factor student insecurity and stress (F3 $\chi^2_{(df\ 1)}$=4.076; $p<0.05$) due to the more pronounced discomfort of high school students (mean rank 80.67) compared to elementary school students (mean rank 66.01). It should be emphasized that a higher percentage of students between ages 14-17 (92.31%) declare that collaboration with scientists gave them a sense of importance (A36) and the importance of the project (A17) than do students between ages 10-13 (73.08%-the importance of the project; the importance of themselves-82.05%). A significant difference according to the age of the students, that is, the level of education, with the Kruskal-Wallis test was observed only with the recognition of the importance of scientists (A35 $\chi^2_{(df\ 1)}$=4.341; $p<0.05$), where it is significant that high school students better recognize the importance of collaboration with scientists.

Other results also showed that stress is a big weight for learning [33]. There is no sense of pressure and competitiveness in the GLOBE program, students agree on having the feeling of a pleasant and collaborative atmosphere and teamwork (3-5 students) while conducting research, especially between older students who are more independent. Scientists monitor the student's work and provide support through all phases of research. All this could also be a key factor in having positive attitudes towards scientists and engaging in science for gifted students and students show a certain interest in science. Collaboration between students and scientists, as demonstrated in the GLOBE program, serves as an effective model for teaching highly motivated and gifted students, potentially increasing their interest in science.

However, this study has its limitations. It focuses on unique face-to-face collaboration, which means that the sample was convenient, and the results cannot be generalized. Future research could explore not only students' attitudes but also the impact of collaboration on knowledge and scientific literacy. It would be valuable to investigate whether interest in science persisted over the years.

4. CONCLUSION

The study revealed students' positive attitudes about face-to-face collaboration with scientists for one year. Students point out scientific and professional development as collaboration advantages. Students think that collaboration with scientists and research should be part of regular classes. Younger students accept criticism better than older students, but older students are more interested in a career in science. Boys are focused on the negative aspects of collaboration, while girls are more focused on the positive effects of student-scientist collaboration on their knowledge. Students think that guiding and supporting them in all phases of research increases not only their motivation, science skills and literacy but also their understanding of concepts. Collaboration between students and scientists, as demonstrated in GLOBE, is an effective model for teaching highly motivated and gifted students, aiming to increase the number of students pursuing careers in science.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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C : **C**onceptualization
M : **M**ethodology
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R : **R**esources
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O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

ETHICAL APPROVAL

The research related to human use has been complied with all the relevant national regulations and institutional policies in accordance with the tenets of the Helsinki Declaration and has been approved by the Ministry of Science, Education, and Youth of the Republic of Croatia.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author, [MB], upon reasonable request.

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APPENDIX

Table 3. Differences between close answers in the categories of highly affirmative and less interested/motivated students

Items		Science less interested/motivated						Science highly affirmative	
		I don't agree at all-I mostly disagree		I mostly disagree-I neither agree nor disagree		I neither agree nor disagree-I mostly agree		I mostly agree-I completely agree	
		Chi-Square	p	Chi-Square	p	Chi-Square	p	Chi-Square	p
A4	Scientists should not be judging students' reports	0.84	0.361	1.57	0.210	13.71	0.000	4.46	0.035
A5	Questions that scientists have asked me were tough	1.67	0.196	0.61	0.437	19.80	0.000	11.00	0.001
A6	When I was presenting my research, the atmosphere was nice	2.57	0.109	5.77	0.016	8.56	0.003	0.24	0.622

Table 3. Differences between close answers in the categories of highly affirmative and less interested/motivated students (continue)

	Items	Science less interested/motivated						Science highly affirmative	
		I don't agree at all-I mostly disagree		I mostly disagree-I neither agree nor disagree		I neither agree nor disagree-I mostly agree		I mostly agree-I completely agree	
		Chi-Square	p	Chi-Square	p	Chi-Square	p	Chi-Square	p
A7	The communication with the scientists was serious and formal	1.60	0.206	23.17	0.000	1.11	0.292	0.89	0.345
A8	The questions were clear	0.67	0.414	10.67	0.001	10.24	0.001	4.60	0.032
A9	Presenting Infront scientists and students is stressful	0.62	0.433	16.52	0.000	2.09	0.149	0.00	1.000
A10	Presenting helped me gain confidence and made me lose performance anxiety	0.00	1.000	10.80	0.001	10.32	0.001	0.01	0.922
A11	I was proud of myself when I answered the questions asked by scientists	0.14	0.705	9.78	0.002	5.79	0.016	14.62	0.000
A12	I think my project has gained in importance due to the evaluation of the scientists	1.80	0.180	23.15	0.000	10.98	0.001	0.04	0.849
A13	I gained a positive opinion of the scientists based on talking to them	5.00	0.025	9.00	0.003	10.88	0.001	4.17	0.041
A14	I felt frightened and insecure when talking to scientists	1.61	0.204	0.33	0.569	4.45	0.035	2.63	0.105
A15	Due to the criticism of scientists, I no longer want to do research	27.30	0.000	5.57	0.018	6.37	0.012	0.14	0.705
A16	During scientific research scientists talked mostly with my teacher not me	0.18	0.670	14.70	0.000	1.71	0.190	2.04	0.154
A17	During scientific research scientists talked to me and gave me some great advice on how to make research better	3.77	0.052	11.52	0.001	2.51	0.113	0.17	0.683
A18	We communicated mostly via e mail with scientists	0.00	1.000	7.71	0.005	3.75	0.053	0.56	0.453
A19	I would love to have more contact with scientists while researching	0.40	0.527	12.50	0.000	9.80	0.002	0.09	0.770
A20	From the communication with the scientists, I learnt about the process of investigation and research	3.00	0.083	5.45	0.020	9.06	0.003	1.58	0.209
A21	During communication with scientists, I learnt more about science topics that I was researching	1.67	0.197	5.12	0.024	14.45	0.000	1.18	0.278
A22	During the communication with the scientists, I learnt more about the science topics that other students were researching	0.00	1.000	17.64	0.000	4.13	0.042	11.37	0.001
A23	The collaboration with the scientists should be part of a regular class	0.33	0.564	9.32	0.002	9.14	0.003	0.24	0.626
A24	Talking to scientists made me feel like a part of a scientific club	1.00	0.317	21.13	0.000	6.53	0.011	0.15	0.700
A25	Scientists made me think critically about my research	1.29	0.257	26.27	0.000	2.42	0.120	1.78	0.182
A26	While investigating and talking to scientists I have learnt to think in a scientific way	5.00	0.025	16.94	0.000	9.12	0.003	0.46	0.499
A27	I gained a better insight into the work of a scientist	2.27	0.132	5.83	0.016	17.33	0.000	0.45	0.503

Table 3. Differences between close answers in the categories of highly affirmative and less interested/motivated students (continue)

Items		Science less interested/motivated						Science highly affirmative	
		I don't agree at all-I mostly disagree		I mostly disagree-I neither agree nor disagree		I neither agree nor disagree-I mostly agree		I mostly agree-I completely agree	
		Chi-Square	p	Chi-Square	p	Chi-Square	p	Chi-Square	p
A28	The scientist encouraged me to do new research	2.00	0.157	9.94	0.002	12.07	0.001	14.23	0.000
A29	Investigations are interesting and should be part of a regular class	0.33	0.564	25.49	0.000	2.25	0.133	3.37	0.066
A30	The criticism of the scientists was useful to me and encouraged me to be better at writing projects	3.57	0.059	16.89	0.000	2.92	0.087	1.18	0.278
A32	In addition to creating the project, I learned a lot about the scientific areas related to my research	2.13	0.144	1.00	0.317	9.94	0.002	0.09	0.761
A33	Creating a project helped me understand the content that was not completely clear to me during the class	1.14	0.285	0.20	0.655	20.64	0.000	5.83	0.016
A34	One day I want to become a scientist	0.36	0.549	18.96	0.000	2.32	0.128	2.32	0.128
A35	The investigation is easier to do with the help of scientists	0.11	0.739	10.67	0.001	18.51	0.000	0.14	0.705
A36	The collaboration with the scientists makes me feel important	-	-	22.00	0.000	13.47	0.000	1.02	0.313

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