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THE INFLUENCE OF PRACTICAL WORK AND THE USE OF SCIENTIFIC RESEARCH METHODS ON THE INTEREST IN THE STEM FIELD OF NINE-YEAR-OLD STUDENTS

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Abstract: The project "With STEM Let's Grow " was developed by the Strategic Plan of the Ministry of Science and Education of the Republic of Croatia for the period 2020-2022. Furthermore, it was developed by the "Science, Education, and Technology Strategy" of the Republic of Croatia in lifelong learning. It is necessary to provide children with many opportunities to participate in research activities that correspond to research carried out in science since through the processes of independent experimentation children acquire relevant skills and learn about the processes of science prevails over applied knowledge among children of younger school age. It is necessary to change the existing situation through frequent and continuous cooperation of the subject and class teacher, and by connecting the teaching of the subject nature and society with the teaching subjects of the STEM area. Intending to improve didactic work in the STEM field in elementary schools, the program "With STEM Let's Grow" was created, which was approved by the Ministry of Science and Education. The one-day version of the program was implemented in 24 schools during the 2021/2022 school year, and 1042 students participated (470 students were in the control group and 572 students were in the experimental group). Assessment of interest in the STEM field was conducted among students who have participated in the program and their peers in the same schools in the 2021/2022 school year who have not participated in it. These groups were compared in terms of their interest in the STEM field.
Keywords: interest, nine-year-old, research activities, STEM

INTRODUCTION

The project "With STEM Let's Grow " was developed following the Strategic Plan of the Ministry of Science and Education of the Republic of Croatia for 2020-2022. Furthermore, it was developed following the "Science, Education, and Technology Strategy" of the Republic of Croatia in the field of lifelong learning.

In the document of the European Commission related to the strategic thinking of education, it is emphasized that it is equally important to acquire transversal and fundamental knowledge and skills from science, technology, engineering, and mathematics (STEM - Science, Technology, Engineering, Mathematics) from an early age. These knowledge and skills are necessary for navigating a technologically dependent society, for later activities in scientific research, and technological development, and serve as a solid foundation for lifelong learning.

It is necessary to provide children with many opportunities to participate in research activities that correspond to the kind of research carried out in science, since through independent experimentation children acquire relevant skills and learn about the processes of science (Martinko, Pavić, 2019). According to research results, formal knowledge prevails over applied knowledge among children of younger school age (Borić, 2009.). It is necessary to change the existing situation through frequent and continuous cooperation of the subject and class teacher, and by connecting the teaching of the subject nature and society with the teaching subjects of the STEM field.

Education for the global age is education for lifelong cognitive, behavioral, and relational engagement with the world (Suárez-Orozco, Sattin, 2007.). The skills and competencies, but also the feelings needed to identify and solve problems from multiple perspectives, require

the education of curious and cognitively flexible students who can tolerate ambiguity and synthesize knowledge within and across different disciplines (Vrkić Dimić, 2013).

Even at the end of the last century, according to the American Association for the Advancement of Science (1993) and National Research Council (1996), it was pointed out that the main goal of education in the 21st century must be focused on the science literacy of students who will possess the skills of critical thinking, interpretation of complex data, and the ability to solve problem tasks.

In research (Glasser, 1994., Ramsden, 1998), numerous authors pointed to the trend of declining student interest in learning science.

Science literacy is today considered one of the key competencies in modern society, which is faced daily with global problems such as lack of drinking water, air pollution, lack of energy, excessive exploitation of natural resources, epidemics, and disease pandemics. Since knowledge about natural sciences and technologies significantly contributes to the personal, social and professional lives of individuals, understanding natural sciences and technologies is a central component of young people's preparedness for life.

According to the PISA test from 2018, and National Center for Foreign Affairs evaluation, when science literacy was tested, the average result of Croatian students was significantly below the OECD average. It is particularly worrying that the results of the test are worse compared to the test from 2006.

Many studies point to the importance of conducting experiments in elementary physics, biology, and chemistry education (Golubović, 2011). Demonstration and student experiments should be used in initial STEM education (Hart *et al.*, 2000). With their help, students can prepare for processing a new teaching unit, for repeating and determining the material, as well as for applying the acquired knowledge (Suen, 2004).

The use of student experiments satisfies children's innate needs for physical activity, as well as the inclination of the children's spirit to examine everything that comes within reach of their senses. Student experiments maximally activate students, because when students perform experiments themselves, they have to pay close attention to what they are doing. Students' interest is greater when they perform experiments themselves because they are curiously waiting to see what will happen in the experiment, whether the experiment will succeed, etc. (Church, 2003).

The influence of the implementation of student experiments on the quantity and quality of fourth-grade students' knowledge was analyzed. 88 fourth-grade students participated in the study (Cvjetićanin *et al.*, 2010): 44 students of the control group and 44 students of the experimental group. The students of the control group were taught about the content using the traditional method, while the students of the experimental group performed student experiments. In the final test and the retest, the students of the experimental group achieved a better result.

With the advancement of science and technology, it is necessary to educate individuals with skills such as creativity, critical thinking and reasoning, investigative thinking, collaboration and problem solving. STEM education paves the way for creativity, productivity, critical thinking, and analytical thinking (Kazu, Kurtoglu Yalcin, 2021). According to that Meta-Analysis Study, STEM education has a great effect on academic success. It is necessary to encourage STEM education in educational institutions and provide the necessary infrastructure.

The integration of technology and engineering into school education has been proposed as an effective means of improving

student learning and increasing student achievement in STEM disciplines (Kazu, Kurtoglu Yalcin, 2021, Dugger, 2010, Sencer Corlu *et al.*, 2014). Technology and engineering activities have been shown to develop STEM literacy and increase motivation while providing a real-world context for learning science and math concepts. Engaging students in activities that are fun, practical, and related to everyday contexts improves students' attitudes toward STEM subjects, which can then encourage them to pursue STEM-based careers (De Witt, Archer, 2015).

RESEARCH PREPARATION, OBJECTIVES AND RESEARCH QUESTIONS

RESEARCH PREPARATION

The research was prepared for implementation in all counties of the Republic of Croatia. The educational program "With STEM Let's Grow " was developed and verified, which was carried out in 22 schools, at least one in each county, and a survey was created that examined the interest in the STEM field among ten-year-olds.

Before the actual research, permissions were requested and obtained from all institutions where the research was conducted, care was taken about the ethical acceptability of the research draft and one's ability and equipment. Respondents were offered participation in the research and decided for themselves whether they wanted to participate.

Since the respondents are children, the consent to participate was filled out and signed by legal representatives (parents/guardians).

At the beginning of the research, the respondents were informed about the nature and purpose of the research, and the results after the collection and analysis of the results.

OBJECTIVE OF THE RESEARCH

This research aims to examine the influence of practical work and the use of scientific research methods in teaching in the form of the Sa STEM program We are growing students' interest in the STEM field in primary schools.

The specific goals are: 1) to check whether there are changes in interest in the STEM field among program participants; 2) determine if there is a difference in interest in the STEM field between girls and boys at the age of 9; 3) examine whether there are differences in interests in the STEM field between boys and girls who participated in the program.

RESEARCH QUESTIONS / HYPOTHESES

Following the statements presented in the introduction and the defined objectives of the research, the following hypotheses were set.

Hypothesis 1: Conducting practical work and using scientific research methods in classroom teaching will increase students' interest in the STEM field.

Hypothesis 2: There is no gender difference in interest in the STEM field among nine-year-olds.

Hypothesis 3: There is no difference in interest in the STEM field between girls and boys who participated in the program.

RESEARCH METHODOLOGY

MEASURING INSTRUMENT – SURVEY

A survey questionnaire with a total of 23 questions was constructed for the research. Two open-ended questions were intended to collect personal data, first and last name, and age, and one closed-ended question (circle the correct answer) was used to collect information about the respondent's gender.

Three open-ended questions (replenishment) had the purpose of collecting information about the final grades in the last grade in the subjects of nature and society, mathematics and informatics.

This was followed by two questions in which the respondents declared whether they had used microscopes or performed experiments at school so far. The following are 15 questions with which respondents expressed their agreement with the offered statement on a 5-point scale (I do not agree/ somewhat disagree, I am not sure/somewhat agree, I agree) which examined interest in the STEM field.

INSTRUMENTARY RELIABILITY AND VALIDITY TEST

Before testing the defined research hypotheses, the reliability and validity of the applied measurement scales were tested.

A pilot study of the comprehensibility of the survey was conducted on a group of 25 participants.

The children had no difficulty in understanding and completing the survey. After that, the reliability of the questionnaire was tested on a sample of 25 respondents (pilot group). The Cronbach's α coefficient on a sample of 15 subjects is 0.92.

The obtained value shows excellent reliability and we can consider the survey appropriate for conducting the test.

The reliability of measurement scales was tested by calculating Cronbach's α coefficients, which is one of the most commonly used coefficients for determining the reliability of measurement scales.

Cronbach's α coefficient is a measure of the internal consistency of a set of statements and can take on values between 0 and 1. The closer Cronbach's α coefficient is to 1, the more reliable the scale is.

An analysis of the reliability of the survey was carried out in such a way that the Cronbach's α coefficient was calculated for the entire survey in the pilot study ($N = 25$) if one question was removed.

The value range of the Cronbach's α coefficient, if an individual question is removed, is from 0.85 to 0.92.

Since the removal of any question does not significantly increase the reliability of the survey, it was decided to keep all the questions in the survey and to conduct the survey with the survey questionnaire in its entirety.

RESEARCH PROCEDURE

The program of one-day workshops was held with nine-year-olds in certain schools in 20 counties during the 2021/2022 school year. years. An average of 25 students attended each workshop. The survey questionnaire was applied to students who participated in the "With STEM Let's Grow" program We also trained students in the same schools who did not participate in it. After conducting the surveys, the interest in the STEM field was compared in both groups of respondents (a total of 1042 respondents participated).

The "With STEM Let's Grow " program was implemented by experts, professors of chemistry and biology, classroom teachers, and assisted by students who had undergone education.

DATA PROCESSING AND ANALYSIS METHODS

The reliability analysis of the questionnaire was measured by calculating the Cronbach's α coefficient.

The data obtained by the questionnaire were statistically processed and compared with each other. Frequencies of individual answers were determined, arithmetic means and standard deviations were calculated for all questions to which the answer was a numerical value.

The share of girls and boys is expressed as a percentage. The final grades at the end of the third grade are expressed in frequencies. In this part of the data analysis, the procedures of descriptive or descriptive statistics that describe the characteristics of the specific sample were used.

Determining statistically significant differences between the groups that participated in the research was done using *the t-test*.

In this part of the research, conclusions are drawn from the specific to the general and a conclusion is made about the population. The methods of inferential statistics or inferential statistics were used.

The data is presented tabularly and graphically, with bar charts, grouped bar charts, pie charts, and complex bar charts.

ETHICAL IMPLICATIONS OF CONDUCTING RESEARCH

The future respondents are children, and minors aged 9 years, and consent to participate in the project was signed by their parents/guardians before the start of the project.

All parents/guardians signed consent for their child and all children in each class who were in class that day participated in the implementation of the program and filled out the questionnaire.

RESEARCH RESULTS

During 2021/2022. During the school year, a one-day program with STEM was conducted we grow in all counties throughout the Republic of Croatia, in 24 schools, in each county at least one elementary school was selected where the research was conducted. Two classes were selected, one as an experimental group and one as a control group. The research participants filled out the survey after participating in the program.

Schools from large and small cities, municipalities, and islands are included in the research. Home and district schools are included. A total of 572 third-grade students participated in the program (Intervention group).

In the same schools, a survey of interest in STEM was conducted in parallel class departments without implementing the program. A total of 470 third-grade students (Control group) participated in the survey.

ANALYSIS OF THE RESULTS OF THE SURVEY CONDUCTED ON THE PARTICIPANTS IN THE ONE-DAY PROGRAM WITH STEM LET'S GROW

GENDER STRUCTURE OF RESPONDENTS

In the questionnaire, all respondents stated their gender. In the control group, the proportion of boys was 52%, with girls 48%, while in the experimental group, the share of boys was 54%, and girls 46% (figures 1 and 2).

Figure 1 : Gender structure of the subjects of the intervention group, N = 572

Figure 2 : Gender structure of subjects of the control group, N = 470

EDUCATIONAL STATUS OF THE RESPONDENT (FINAL GRADES IN THE PREVIOUS SCHOOL YEAR)

According to the final evaluations, in the year preceding the year of implementation of the research, in the school subjects nature and society, mathematics, and informatics, it was observed that there was no statistically significant difference between the intervention and control groups.

CONDUCTING PRACTICAL WORK AND USING SCIENTIFIC RESEARCH METHODS IN EARLY ELEMENTARY SCHOOL EDUCATION

Surveying a sample of 1042 respondents (572 belong to the intervention group, N_I; 470 belong to the control group, N_K) showed that the intervention increased the number of children who used microscopes at school, while no statistically significant difference was observed in the number of children who performed experiments at school (table 1, figure 3). It was observed that most children until the implementation of the Sa STEM program raSTEMo did not have the opportunity to use the microscope. The difference is statistically significant (table 2, figure 4).

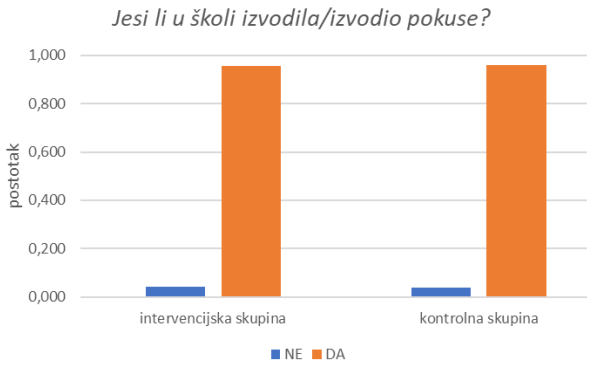

Figure 3: Graphic representation of the frequencies of answers to question 7. Did you perform experiments at school?

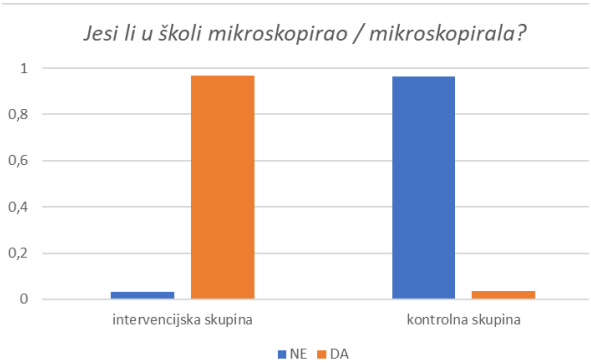

Figure 4: Graphic representation of the frequencies of answers to question 8. Did you use a microscope at school?

By conducting multiple *t-tests* (t-tests for each question), a statistically significant difference is observed in the answers to questions numbered 9, 10, 11, 15, and 16 (table 5).

A statistically significant difference between the intervention and control groups in the responses to the respondents' survey questions was obtained for those questions that examined interest in practical work and experimental methods of work:

9th question = In nature lessons, I would like to carry out practical work that will teach me more.

Question 10 = I would like to use more materials that stimulate my curiosity in nature and society classes.

11th question = I would like to see materials that encourage curiosity be used more in the teaching of nature and society, even if they are very difficult.

Question 15 = I am interested in how clouds are formed.

16th question = I am interested in how a debt is created.

	$N_I = 572$ $N_K = 470$	f_{AND}	$\%_{AND}$	M_{AND}	SD_I	f_K	$\%_K$	M_K	SD_K
1	NOT	24	4.2	0.96	0.19	18	3.9	0.93	0.26
2	THAT	548	95.8			452	96.1		

Table 1: Overview of frequencies of responses to statement 7: I performed experiments at school this year P = 0.05, Question 7: Did you perform experiments at school?

	$N_I = 572$ $N_K = 470$	f_{AND}	$\%_{AND}$	M_{AND}	SD_I	f_K	$\%_K$	M_K	SD_K
1	NOT	18	3.1	0.85	0.36	454	96.6	0.18	0.38
2	THAT	554	96.9			16	3,4		

Table 2: Overview of frequencies of responses to statement 8: I used a microscope at school this year P = 0.01, Question 8: Did you use a microscope at school ?

$N_I = 572; N_K = 470$	M_{AND}	SD_I	M_K	SD_K	p
Question	4.66	0.68	4.42	0.79	< 0.0001
Question	4.68	0.59	4.36	0.82	< 0.0001
Question	4.22	1.02	3.60	1.44	< 0.0001
Question	4.27	1.21	3.57	1.45	< 0.0001
Question	3.28	1.6	2.57	1.43	< 0.0001

Table 5 : Overview of the results of statistically significant differences (t-test)

Students who participated in the educational program "With STEM Let's Grow" show more interest in the STEM field (they are more interested in how clouds and rainbows are formed).

Furthermore, the participants of the educational program express a greater desire to perform practical works and experimental activities that stimulate their curiosity, and they actively participated in such activities by participating in the educational program With STEM we are growing.

Analyzing the data after the one-day program "With STEM Let's Grow" can confirm hypothesis H1: Conducting practical work and using scientific research methods in classroom teaching will increase students' interest in the STEM field.

EXAMINATION OF SEXUAL DIFFERENCES OF INTEREST IN THE STEM FIELD AMONG NINE-YEAR-OLDS

Figure 5 shows the differences in the mean values of answers to the questions asked between boys and girls. Statistically significant gender difference in ten-year-olds who participated in the one-day educational program "With STEM Let's Grow" was observed in the answer to question 17 (I think the knowledge from the subject of informatics will be useful in my life.). It was observed that girls think that the knowledge of computer science will be useful in their life more than boys think.

In the control group, no statistically significant gender difference was observed in the answers to the questions for any of the questions asked, and the graphic representation of the comparison of the mean values of the answers of girls and boys who did not participate in the educational program "With STEM Let's Grow" is given in Figure 6.

Since there is a statistically significant difference between girls and boys after the intervention and introducing students to practical work methods, hypothesis H2 is rejected: There is no gender difference in interest in the STEM field among nine-year-olds, and further research is recommended.

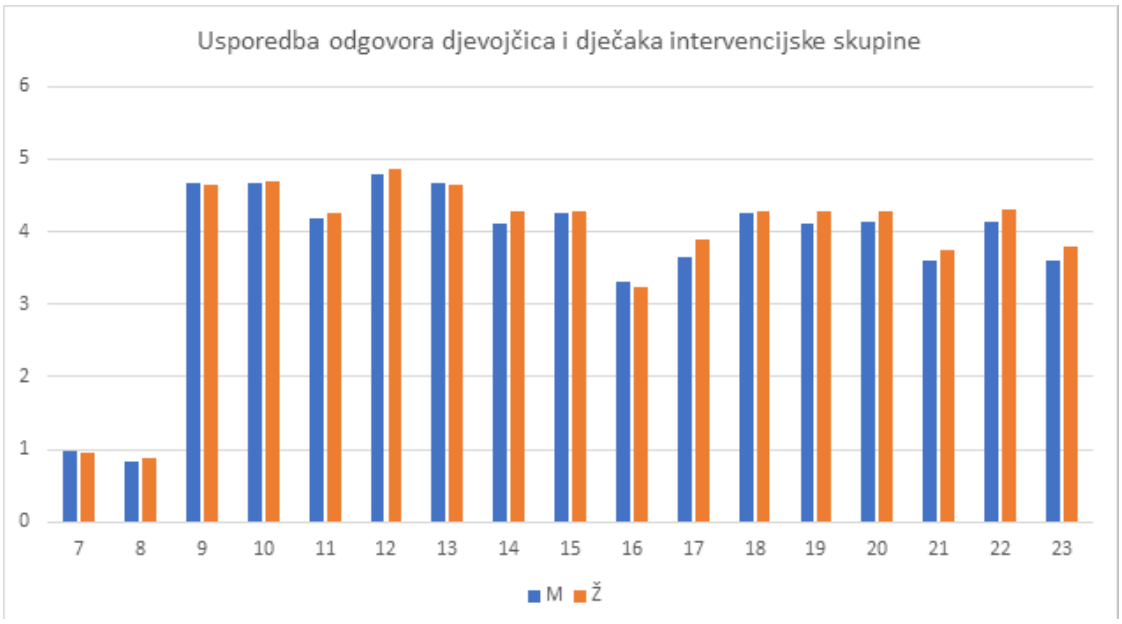

Figure 5: Graphic representation of the comparison of the mean values of the answers of girls and boys of the intervention group to the questions asked in the survey questionnaire. N_I=572

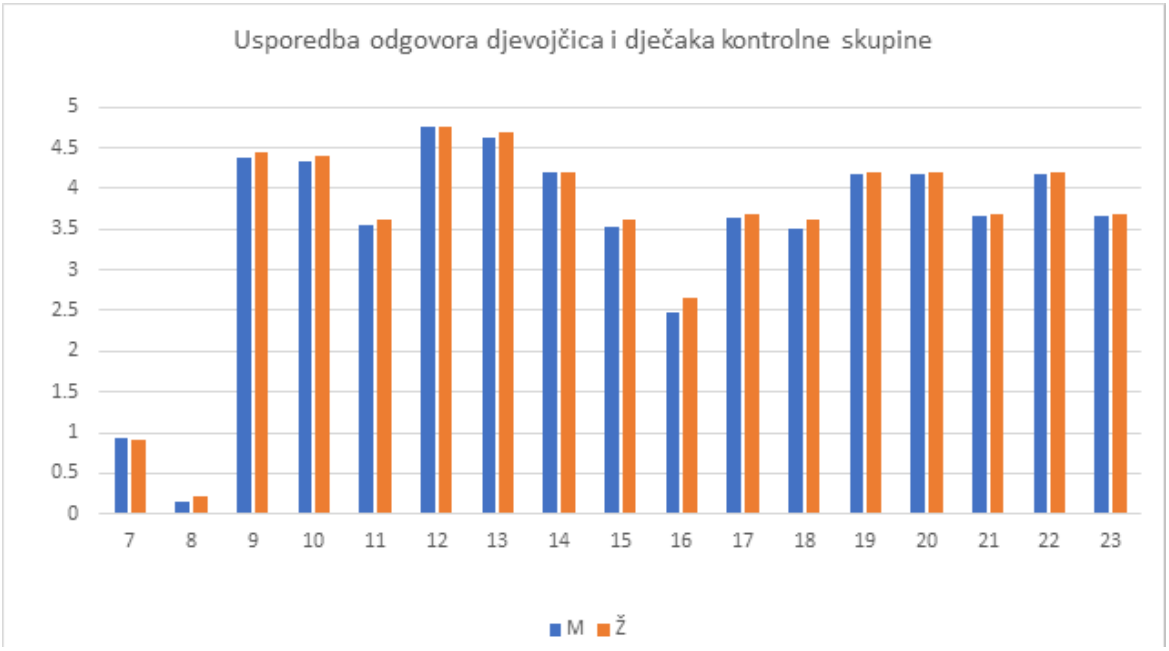

Figure 6: Graphic representation of the comparison of the mean values of the answers of girls and boys of the control group to the questions asked in the survey questionnaire. N_K = 470

CONCLUSION

Primary school students in the Republic of Croatia do not have the opportunity to use microscopes in class, and they rarely perform experiments and practical work. Nine-year-olds are students in the third grade of elementary school whose school curriculum includes subjects from the STEM field - nature and society, mathematics, and computer science. Students show interest in the mentioned subjects and express their desire to participate in experiments and practical activities.

The program "With STEM Let's Grow" was conducted, which was verified by the Agency for Education and the Ministry of Science and Education, and through which students had the opportunity to perform experiments, use microscopes, and research. A survey was conducted with students after participating in the educational program (intervention group) and with students who did not participate in the program (control group), and a statistically significant difference in interest in the STEM field was observed among students who participated in the STEM program compared to those who did not. had the opportunity to try experimental methods and practical work.

Furthermore, the research showed that there is no statistically significant difference in interest in the STEM field between girls and boys who did not participate in the STEM program, while a statistically significant gender difference appears in the experimental group - among students who participated in the Sa STEM program we are growing. Girls show more interest in the STEM field than boys.

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