Developing positive attitude towards science and mathematics through motivational classroom experiences

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Abstract
This paper presents results of a survey among school children aged 10 to 14 years, who participated in science or mathematics workshops. It particularly relates to their interest and motivation determined immediately after the workshop had finished. A total of 70 workshops were held in elementary schools of Rijeka, Croatia, involving the participation of 1240 students aged from 10 to 14 years. The workshops were designed in order to encourage active engagement in class work and a deeper approach to learning stemming from meaningful involvement in a real problem related to everyday life. The results of the survey on student's attitudes towards science and mathematics after the workshop indicated that students accept this type of lesson eagerly, they value demonstrations, applications and practical, hands-on experimentation, and that after this type of classroom activity they express positive attitude towards science and mathematics.
Keywords: Positive attitude towards science and mathematics, primary education, science education, mathematics education.

Introduction
Understanding the content and processes studied by science is crucial for the understanding of numerous challenges of modern society – new technologies, sustainable development, energy crisis and similar (Sevgi, 2006, Özdem et al., 2010). Despite that, and despite various efforts, it seems that fewer young people show interest in science, engineering and mathematics (Osborne, Simon & Collins, 2003; Eurobarometer, 2005; Hodge, 2006). Some authors (Rocard et al., 2007) find this situation alarming and consider it as a threat to the future of Europe. Results of the research conducted by the Organisation for Economic Co-operation and Development (OECD) show that in the last decade, despite democratization of the higher education and increasing number of university students, the number of science students is in decline (compared to other fields of study), and in the fields of mathematics and physics, the decline also refers to the number of students in total (OECD, 2006).

Does the reason lie in socio-cultural changes? Or is it in the inefficient methods of science and mathematics teaching? A majority of studies show that causes for the lack of interest in science can often be found in the manner in which these subjects are taught in schools (Murphy & Beggs, 2003). There is a strong connection between the attitudes towards science and the manner in which they are taught (Osborne et al., 2003; Breen, Cleary & O'Shea, 2009). A study called "Europeans, Science and Technology" (Eurobarometer, 2005) indicates that only 15% of Europeans are satisfied with the way science are taught in schools.

Respondents consider science classes to be the basic reason for the decrease in the interest for the field, and 59.5% of the respondents find them unchallenging and uninteresting. The practice in schools, as well as research results, indicate that it is of crucial importance to work on the innovative curriculum and different approach to the teaching of science and mathematics. These different approaches primarily deal with the problem of low motivation and the students' lack of interest in science and mathematics. We need to bear in mind that recent studies (Eurydice, 2006; Osborne & Dillon, 2008) show that children develop basic interests (including interest in science) prior to 14 years of age. For example, OECD's report on student interest in science and technology studies (OECD, 2006) highlights the great influence of positive contacts with science at an early age on the formation of attitudes towards science later in life. The report also indicates that preschool children have naturally developed curiosity about science, but formal education can suppress their interest and therefore have a negative impact on the further development of positive attitudes towards science.

It seems that to increase students' interest and competence in the field of science, we need to develop and accept a different approach to teaching science (Bonwell & Eison, 1991; Gagliardi, Grimellini Tomasini & Pecori 1999; Karsai & Kampis, 2010). Needless to say, for that reason teachers' competences must be researched and improved, especially their scientific literacy and the ability of communicating scientific topics (Evans & Rennie, 2009). The transformation of the teaching practice in Europe is a long-term project which will require substantial investment in educational systems and teacher training.

To respond to these challenges against traditional teaching approach, i.e., deductive, top down teaching (from conclusions to the experiment), educational science is developing new, student-oriented teaching paradigms (inductive approach, directed from the research to the conclusions) – e.g., problem-based learning (PBL), inquiry-based science education (IBSE), constructivist and project learning (Enghag, Gustafsson & Jonsson, 2004; Rocard et al., 2007; IAP, 2010). One valuable approaches was developed through the PARSEL project, which explored ideas for making science subjects better appreciated by students, by raising popularity (liked by majority of students) and relevance (sense of usefulness of the learning) of science education (Holbrook, 2008; Rannikmäe, Teppo & Holbrook, 2010). What all modern approaches have in common is the student active engagement in the classes (in mental and physical terms), which is regarded as a condition essential for developing interest, understanding and long-term knowledge. By student's mental active class engagement we mean classes in which the teacher initiates the subject through problems of everyday life or performing experiments with everyday objects, thus motivating students to relate their experience with the subject and sense the relevance of the knowledge they are about to gain; by physical active engagement we mean the class that is performed without students undergoing physical restraints (of sitting in one place) and allowing the students to experiment themselves. In this sense, active learning and active lessons are considered to be the approaches to teaching and learning that encourage higher level of student independence and apply different thinking strategies and specific cognitive skills which enable the distinguishing of important information, their analysis and comparison, as well as connection to the previous knowledge and critical judgment.

"Development of Scientific and Mathematical Literacy through an Active Learning" Project

There is a general agreement that teaching science does not result in adequate education and necessary competences of the student. Consequently, a question emerges about the way in which the teaching of science in schools would meet the students' needs: both the students who would continue their education in science and mathematics, and the ones who need just elementary education in the subjects. Analyses show that in a large number of countries the curriculum for science is considerably influenced by the scientists in the field (Osborne & Dillon, 2008), who consider teaching science as a basis for further education in the same field, i.e., for becoming a scientist, or expert. However, we need to ask ourselves to what extent does that kind of education fulfill the needs of the student majority, who need elementary knowledge about basic scientific ideas and concepts and in the way they can use that knowledge in everyday life. The research results (Cooper & McIntyre, 1996; Osborne et al., 2003) show the way in which science is taught, as well as the content of such lessons, do not succeed in motivating students and develop their interest in science. Bearing in mind the complexity of links between students' motivation and the use of learning strategies (Berger & Karabenick, 2011), one cannot be satisfied with this situation and researchers in mathematics and science education need to make an effort in looking for ways to make mathematics and science education less dry and more attractive (Da Silva Figueura-Sampaio, Elias Ferreira dos Santos & Arantes Carrijo, 2009; Siew-Eng, Kim-Leong & Siew-Ching, 2010). It is in this scenario that the "Golden Section" Society , an NGO from Croatia, proposed the project titled "Development of scientific and mathematical literacy through active learning" within a competition by the Ministry of Science, Education and Sport of the Republic of Croatia. The project was presented as a three-year activity in cooperation with Rijeka's City Department of Education and Schooling which enabled contacts and coordination with the principals and teachers of all primary schools in Rijeka. The realization of the project was approved, started in the late 2007 and ended in mid 2010.

The goal of the project

The project was envisioned as an attempt to encourage science and mathematics school teachers to implement active teaching with their students, in a way similar to that learned through the model workshops. The basic idea for the development of the project was that the teaching of science and mathematics must not simply be based on the motivation and abilities of the minority of students who plan to continue their education as scientists or experts in the field of science or mathematics, but that it should be adapted for all students. The aim of the project was for students to develop their interest and motivation, understanding and long-term knowledge of science and mathematics which they will use (irrespective of their future careers) in everyday life and which will help them, as responsible and competent citizens interested in the field, make qualified decisions about matters of public interest. In other words, the primary goal of the project was to develop interest in the field of science and mathematics, not only among the students already showing interest in the field, but among the whole school population. It was recognised as important to emphasize the extreme importance of scientific and mathematical knowledge and interest for students of engineering, medicine, etc., who are indirectly related to such knowledge, and who, partly because of the lack of interest, odium or insecurity in their own competences, avoid applying for such studies, which are often in deficit.

The realization of the project

In the preparatory stage of the project, we designed and organized workshops and planned a survey to examine the experiences and attitudes of students participating in the workshops. Six physics workshops were prepared: "Story about air", "Story about currents", "Story about balance", "Why do bodies float?", "How do we see objects?" and "How does liquid surfaces react?", plus six with topics in mathematics: "Let's play circles!", "Mathematical origami", "Golden section", "Help Joseph Kruskal!", "Experimental determination of π" and "Sudoku and math." After every workshop, a survey about this kind of classroom activity, experiences and attitudes toward the subject was conducted among the participants. During two academic years, 2007/08 and 2008/09, at least 3 workshops were held in each of the 23 primary schools in Rijeka. In that way, in 2 years, 70 workshops were carried out, 35 mathematics and 35 physics workshops, in which a total of 1240 students participating. The third year in the project's realization was spent analyzing the survey data and composing a book with detailed description of workshops, the methodological approach used and research findings (Rukavina et al, 2010).

Through research based on the survey among participants, we wanted to explore if participation in the workshops was a positive experience for the students, and whether the student's attitudes toward mathematics or physics, as subjects, were positive after attending a workshop. If so, we felt this can be the beginning of the development of positive attitudes toward mathematics and science for those students who previously held no interest in these subjects and, possible, attending a number of workshops, can contribute to maintaining a positive attitude for a long time.

The class workshops were designed as educational content delivered by two persons (one academic teacher and one student to become a teacher) lasting from one to two lessons (45-90 minutes) with (on average) 15-20 students taking part. The workshop topic at the beginning was presented by posing a problem in everyday life or performing some experiments with everyday objects, accompanied by questions to students, engaging them in dialogue. Then, in most cases, new scientific or mathematical terms were introduced (as balance, floating, pressure, flow, golden section, Platonic solid, Latin square) and their presence or meaning found (or put) in different contexts and situations. New terms were also related to already established knowledge and related to previously adopted terms. Much experimentation in this phase happened (both in math and science workshops). Finally, in the third part, students were engaged in applications of their newly gained knowledge by trying to solve a posed problem (again situated in an everyday context) or to experimentally check solutions to the problem. For example, in the workshop "Story about balance" participants checked the stability of piled stacks of chocolate bars or CD covers, and in "Help Joseph Kruskal!" they found the fastest way for visiting all places on a given map.

We believe that this kind of active learning, in terms of constant activity of students throughout the workshop (mental or physical), contributes to the quality and applicability of the acquired knowledge. The methodological approach used in carrying out the workshops was constructivist – through the introductory part, the previous knowledge is questioned and solid grounds (right conceptions) detected; the construction of new knowledge was supported by contextualization and application to problem solving.

Additional feature of the workshops was the presence of school subject teachers who regularly teach science or math classes with the same students; this gave teachers the opportunity to see how their students reacted to this type of classroom performance and to start to reflect on their teaching practice and learning styles of the students. In many cases, this was a starting point to motivate the teachers to change their teaching practice and start improvements.

Beside all this, a particular opportunity of participating in design and delivery of workshops was given to academic students of mathematics and/or physics educational studies. In this way they had a chance to do both experimentation with educational design and undertake research.

The goal of this project was to examine whether the students willingly accept active engagement in their lessons, whether they take part in it eagerly, regardless of their general attitudes towards science and mathematics, and whether this type of learning develops positive attitudes towards science and mathematics. A pilot project and research were conducted prior to the project realization, which generated our expectations that the workshops would develop positive attitudes towards science and mathematics. In this paper we will present part of the findings from the research about the acceptance of active teaching of science and mathematics in the primary schools in Rijeka, Croatia.

Research Methodology

Participants

The survey was distributed to all the students (4th to 8th grade, or from 10 to 14 years of age) who participated in the workshops as a part of the “Development of scientific and mathematical literacy through active learning” project (1240 students), and 1222 completed surveys were collected, giving a 98.5 % response. The responses were very similar in the physics workshops (586 /591 respondents = 99 %) and the mathematics workshops (636 / 649 respondents = 98 %). Since the workshop participants were the full class units (or their valid representatives) in a school, it can be said that the sample is representative of the certain age of students.

Research tool: survey

Students were given the survey sheet immediately after the workshop was over. Since the research sample was heterogeneous with respect to age, the questions were short and simple, designed in a way that all children could answer in a short period of time.

The first question in the questionnaire was asking students to decide how much they like math/science in comparison to other subjects, with 5 possible answers (not at all, less than other subjects, more than other subjects, the most). The next question asked students to judge how much they have learned during the workshop in comparison to regular class lessons (with possible answers less, the same, more). The third question considered student’s preference for this type of teaching and learning, where students could choose answers: “This one workshop was enough”, “From time to time I’d like to have workshops like this” and “I’d prefer this type for the majority of class lessons”. Next, students were asked to give the score for the workshop that was just delivered (on the scale 1-5), and then to give comments on two open questions (what did I like the best, and what did I like least).

Statistical analysis of the collected data was performed using the statistical software package STATISTICA, StatSoft, Inc. 2007, v 8.0 (www.statsoft.com). The collected data was described and analysed with appropriate statistical methods.

Results

According to the described methodology, 35 workshops in mathematics and 35 workshops in physics were planned and realized, with 1240 elementary school students participating. All students completed the survey sheet immediately after the end of the workshop, and 1222 completed sheets were collected (Table 1).

Table 1. Overview of the number of students participating in the survey according to the workshops and age

Subject	Title of workshop	Number of students				TOTAL
		4th grade	6th grade	7th grade	8th grade	
Physics	The tale about flow	0	0	54	47	101
	How do we see objects?	0	39	65	0	104
	The tale about air	29	39	26	0	94
	The tale about balance	0	0	57	48	105
	Why do bodies float?	13	0	71	0	84
	Surface tension	0	0	0	98	98
	Subtotal	**42**	**78**	**273**	**193**	**586**
Mathematics	Sudoku and math	0	0	58	36	94
	Experimental determination of π	0	0	0	102	102
	Help Joseph Kruskal!	0	20	20	73	113
	Mathematical origami	0	0	35	77	112
	Golden section	0	20	57	22	99
	Let's play circles!	116	0	0	0	116
	Subtotal	**116**	**40**	**170**	**310**	**636**
	Total	**158**	**118**	**443**	**503**	**1222**

The workshops were held for 4th, 6th, 7th and 8th grade students. Considering suitability of workshop content to certain age groups, not all the workshops could be delivered to all age groups. Only a few workshops could be held for the youngest students, and most were held in 7th and 8th grades. In physics workshops the majority of the participants were from the 7th grade, while the majority of mathematics workshop participants were from the 8th grade. According to the certain workshop topics, there is a fairly equal number of participating students - around 100 (Table 1), which shows there is a good balance of the research sample regarding the acquired experience.

How much do I like mathematics or physics in comparison to other subjects?

A frequency analysis of certain responses to the first question ("In comparison to other subjects, I like mathematics/physics...") was created according to the age of the students (4th to 8th grade). To simplify the interpretation of the responses, the answers were categorized in two groups: "like less" and "like more" (Table 2).

Table 2. Frequency of certain answer categories to the survey question "How much do I like math/physics in comparison to other subjects?" according to students' age

Subject of workshop	Grade	I like mathematics/physics ...			
		Less than other subjects		**More than other subjects**	
		Number of students	share	Number of students	share
Physics	4th	10	24%	32	76%
	6th	6	8%	72	92%
	7th	40	15%	233	85%
	8th	50	26%	143	74%
	Subtotal	106	18%	480	82%
Math	4th	42	36%	74	64%
	6th	19	48%	21	53%
	7th	37	22%	133	78%
	8th	69	22%	241	78%
	Subtotal	167	32%	469	68%
All	4th	52	33%	106	67%
	6th	25	21%	93	79%
	7th	77	17%	366	83%
	8th	119	24%	384	76%
	TOTAL	273	24%	949	76%

The survey indicates that there is a higher, statistically relevant, frequency of the answer “like more” among students of 6th and 7th grades (Pearson's chi-square test, □2=150.0, $p<0.001$). In physics workshops the mentioned answer is most frequent in 6th grade and still significantly frequent in 7th grade. In mathematics workshops, the answer “like more” is significantly more frequent in 7th and 8th grades. The analysis of the answers to this question indicates positive attitudes towards learning of mathematics and physics, where 76 % of students, regardless of the workshop attended, claim to like these subjects more than other subjects. However, since the students completed the survey immediately after the end of the workshop, the direct experience of the workshop and excitement about the specific content should be taken into account. Nevertheless, the sole fact that students are expressing positive attitudes towards the subjects immediately after experiencing a different manner of teaching, supports the assumption that the manner of teaching is a key factor in motivating and developing interest in science and mathematics.

How much have I learned in this workshop in comparison to regular lesson?

Analysis of the responses to this survey question is presented in Table 3. It shows the results of students' evaluation about the quantity of acquired knowledge in workshop type of lessons in comparison to regular lessons, according to their age.

Table 3. Frequency of certain answer categories to the survey question "How much have I learned in this workshop in comparison to regular lesson?" according to students' age.

Subject of workshop	**Grade**	**In this workshop I have learned…**					
		Less than in regular lesson		**Same as in regular lesson**		**More than in regular lesson**	
		Number of students	share	Number of students	share	Number of students	share
Physics	4th	6	14%	0	0%	36	86%
	6th	3	4%	0	0%	75	96%
	7th	60	22%	12	4%	201	74%
	8th	19	10%	12	6%	162	84%
Subtotal		88	12%	24	3%	474	85%
Math	4th	38	33%	6	5%	72	62%
	6th	5	13%	1	3%	34	85%
	7th	58	34%	11	6%	101	59%
	8.	64	21%	21	7%	225	73%
Subtotal		165	25%	39	5%	432	70%
All	4th	44	28%	6	4%	108	68%
	6th	8	7%	1	1%	109	92%
	7th	118	27%	23	5%	302	68%
	8th	83	17%	33	7%	387	77%
TOTAL		253	20%	63	4%	906	76%

With this question, the highest frequency of the answer “more than in regular lesson” for all workshops is among students of 6th grades. According to subjects, the mentioned response is significantly more frequent among 4th and 6th grade students in the physics workshops, and among 6th and 8th grade students in mathematics workshops (Pearson's chi-square test, $\chi^2=172.1$, $p<0.001$).

Overall, more than ¾ of participants in the workshops claim to acquire knowledge better through active learning than in traditional lessons. However, it is important to point out that one third of 4th and 7th grade students believe that the content in mathematics is better acquired through regular lessons. Naturally, these findings should be interpreted with caution since they express students' evaluation of the acquired knowledge, and not the objective results based on the comparison of learning results after acquiring knowledge in regular lesson and workshop lesson.

Would I like this type of lessons to become regular?

This survey question was designed to determine whether students prefer this, somewhat different type of lessons which requires their active involvement. Students' preferences regarding the manner of teaching are presented in Table 4.

Table 4. Frequency of certain answer categories to the survey question "Would I like this type of lessons to become regular?" according to students' age

Subject of workshop	Grade	Would I like this type of lessons to become regular?					
		The workshop was enough		From time to time		I prefer this type	
		Number of students	share	Number of students	share	Number of students	share
Physics	4^{th}	4	10%	12	29%	26	62%
	6^{th}	5	6%	15	19%	58	74%
	7^{th}	16	6%	83	30%	174	64%
	8^{th}	2	1%	36	19%	155	80%
	Subtotal	27	6%	146	24%	413	70%
Math	4^{th}	5	4%	39	34%	72	62%
	6^{th}	3	8%	17	43%	20	50%
	7^{th}	15	9%	70	41%	85	50%
	8^{th}	21	7%	87	28%	202	65%
	Subtotal	44	7%	213	36%	379	57%
All	4^{th}	9	6%	51	32%	98	62%
	6^{th}	8	7%	32	27%	78	66%
	7^{th}	31	7%	153	35%	259	58%
	8^{th}	23	5%	123	24%	357	71%
	TOTAL	71	6%	359	30%	792	64%

With this question, the high frequency of the answer "I would prefer this type for majority of lessons" is equally present among the participants of all ages. In physics workshops this attitude is expressed more often than in mathematics workshops (Pearson chi-square test, χ^2=137.0, p<0.001). In physics workshops the preference towards active learning is expressed the most among 6th and 8th grade students (around 80 %), and in mathematics workshops in 4th and 8th grade (more than 65 %). The result supports basic assumptions on which this project was founded and which refer to the need for altering the dominant frontal approach in teaching and passive learning of mathematics and physics.

Evaluation of the workshops

Students were asked in the survey sheet to rate the workshop as a whole, using scores from 1 – bad to 5 – excellent. Table 5 shows the scores, expressed in mean value, and standard deviations, processed according to students' age. Scores are compared in relation to students' age (analysis of variance test, ANOVA). Results indicate that physics workshops are rated statistically significantly lower in 7th grade, while scores for the mathematics workshop do not differ according to students' age (which gives higher importance to the difference for all workshops, regardless of the field). With both workshops, mathematics and physics, there is a tendency among students to give lower scores to the workshops as they are older. The reason for it can be simply the general development of critical thinking, as would be expected at that age.

Table 5. Scores for the workshops according to students' age

Subject of workshop	Grade	N	mean	SD	Level of statistical significance*
Physics	4th	42	4.9	0.3	< 0.001
	6th	78	4.9	0.3	
	7th	273	4.6	0.7	
	8th	193	4.8	0.5	
Math	4th	116	4.8	0.6	0.076
	6th	40	4.7	0.5	
	7th	169	4.7	0.6	
	8th	310	4.6	0.6	
All	4th	158	4.8	0.5	< 0.001
	6th	118	4.8	0.4	
	7th	442	4.6	0.7	
	8th	503	4.7	0.6	

*level of statistical significance calculated using analysis of variance method

However, it can be noticed that physics workshops are scored statistically significantly lower in the 7th grade, which is at the time when physics occurs as a separate subject in Croatian elementary schools. From this aspect, it can be interpreted that the new subject does not meet students' expectations, or that they have experienced failure regarding the subject, or (after only describing nature in lower grades) they are taken aback by the new approach to learning physics (introducing the mathematical aspect, calculating), which can all lead to the reduced interest and enthusiasm for the field.

Analysis of the students' comments

We were interested in the students' comments about the workshops as well, so the survey had open type questions, for describing their positive impression (What did you like best in the workshop?) and a comment where they could express their opinions on improving the workshops, i.e., their critical review of the workshop (What would you change, what did you like least?).

A Majority of students expressed their opinions, only 54 survey sheets (4.4 %) did not contain any comment.

For the question “What did you like best in the workshop?” 1168 comments were analyzed and grouped into smaller categories of similar or identical meanings (Table 6).
Table 6 shows various frequencies of answer categories. With both subject workshops there is a high frequency of the answer “I liked everything”, which indicates students' general positive attitude towards the workshop. The comment category “I have learned something new” indicates a positive attitude towards the workshops, which refers not only to learning something new, but also to human need for learning and acquiring competences which is extremely positive and should be further encouraged.

It is shown that in the physics workshops, students value experiments the most (67 %), and in the mathematics workshops practical work (24 %), which indicates that in all workshop subject students find demonstration and application extremely valuable. However, the results indirectly show that in regular physics lessons not enough experiments are included so the students were delighted with them, and that regular lessons in mathematics do not contain enough practical application of the knowledge.

Despite the high quantity of comments in favour of experiments/practical work, it should be further examined how this approach, as opposed to traditional lessons, influence acquiring long-term knowledge, how it increases students' interest in the subject and fortifies their key competences, and how it does not remain merely an “interesting” approach.

Table **6**. Frequency of certain answer categories to the survey question "What did you like best in the workshop?” according to the workshop subject

Answers to survey question "*What did you like best in the workshop?”*	Subject of workshop: **Physics**		**Mathematics**		**All**	
	Number of students	share	Number of students	share	Number of students	share
Experiments	376	67%	17	3%	393	34%
Everything	84	15%	98	16%	182	16%
Practical work	1	0%	145	24%	146	13%
Team work	0	0%	87	14%	87	7%
The manner of explaining, demonstrating and reaching conclusions	52	9%	31	5%	83	7%
Creative problem solving, interesting and amusing	0	0%	73	12%	73	6%
I’ve learned something new	10	2%	49	8%	59	5%
Interesting and fun way of learning, like playing a game	1	0%	43	7%	44	4%
Content	1	0%	24	4%	25	2%
Applicability	20	4%	2	1%	22	2%
Other	18	3%	36	6%	54	5%
TOTAL	563	100%	605	100%	1168	100%

The question “What would you change, what did you like least?” got fewer comments (1071), with 151 survey sheets (12 %) contained no comment. The comments, as with previous question, were grouped into categories with similar or identical meaning, as shown in Table 7.

From the results shown in the table, it is evident that the majority of comments are once again positive, which indicates further that students eagerly accept this type of teaching approach. A small number of students (N=7) complains about team work (in category “other”), but from the formulation of their comments it is evident that these students are not used to working in groups, and one student stresses too much repetition. However, the lack of comments that would indicate dissatisfaction with active learning enable us to make a general conclusion about good acceptance of active learning from elementary school students, regardless of the subject.

Table 7. Frequency of certain answer categories to the survey question "What would you change, what did you like least?" according to the workshop subject.

Answers to survey question "What would you change, what did you like least?"	Subject of workshop					
	Physics		Mathematics		All	
	Number of students	share	Number of students	share	Number of students	share
Nothing needs to be changed, I liked everything	390	75%	451	82%	841	79%
It should last longer	53	10%	31	6%	84	8%
It needs more experiments and tasks!	26	5%	13	2%	39	4%
I want more workshops like these!	10	2%	20	4%	30	3%
I liked some experiments	21	4%	0	0%	21	2%
I liked this kind of calculating	0	0%	17	3%	17	2%
Other	18	3%	21	4%	33	3%
TOTAL	518	100%	553	100%	1065	100%

Discussion

The studies show that in teaching of science a “leading” approach is the dominant one (Osborne & Dillon, 2008): teachers see themselves primarily as carriers of the *scientific canon* and their teaching is usually teacher oriented. Moreover, teachers often use the method “copy-it-from-the blackboard” because it gives them a sense of security (Eurydice, 2006). Furthermore, the methods based on students' own research, which would make the content clearer, are avoided. Science and mathematics are most often taught in an abstract way: the subjects are based on the science laws and facts, with insufficient experimenting, monitoring and interpretation, which results in misunderstanding and a perception of the science as difficult and irrelevant in everyday lives. There can be a lot of obstacles facing teachers doing practical activities in their classrooms and often they need help for introducing different way of teaching (Fisher, 1998). Attendance to the workshops gave teachers the opportunity to see how their students react to this type of classroom performance and to start to reflect on their teaching practice. The same opportunity is given to the academic students.

Through the “Development of scientific and mathematical literacy through active learning” project, a few workshops have been designed in the form of model lessons which encourage students to get actively involved in the lesson. The workshops encourage an active and deeper approach to learning which stems from sensible work on a real problem related to everyday life. The research conducted during the participation in workshops indicated that students accept this type of lessons eagerly, that they value demonstration and application, 47% of students states that they “like the most” experiments (34%) or practical work (13%), and 16% of them like “everything” in the workshop (including experiments and practical work).

The content of each workshop generates understanding of basic ideas and principles of a certain scientific of mathematical topic, and, by way of teaching manner, we try to create an atmosphere with a tendency to develop positive feelings towards science and mathematics lesson and learning..

The results of the research show further that immediately after the end of the workshop about ¾ of the students claim to like physics or mathematics better than other subjects. Having been used to different experiences, perceptions and facts (lack of interest in the study of mathematics and physics at the University of Rijeka, finding mathematics and physics difficult school subjects, etc.) which indicate different preferences toward school subjects, these results were surprising, but also they provided a perspective. These results were somewhat influenced by the students' direct participation in the workshop (so it would not be appropriate to conclude that students would express identical attitudes towards the subjects in a different situation) and the fact that they express positive attitudes towards the subjects immediately after experiencing a different teaching approach supports the conclusion that the approach is a key factor in motivating and developing interest in science and mathematics. The findings also indicate that 76 % of students express an opinion that this kind of class performance makes the learning process better and easier, while 68% of the students would like this type of approach in regular lessons as well. The comments on the survey sheets indicate that students find demonstrations, experiments and applied calculations extremely important, which evidently provide good context for acquiring new concepts. Furthermore, cooperation with both teacher and fellow students makes this approach accountable for better and easier learning than in regular lessons. One can say that this is because they are "playing all the time during the workshops" but when asked "*What did you like best in the workshop?"* just 10% of the students answer in terms of amusement and play and even these students answers emphasise creative problem solving (6%) or a fun way of learning (4%) more then amusement and play themself.

These results are in line with other researcher's findings (Oh & Yager, 2004) and suggest that the majority of students feel comfortable with the change of the traditional frontal approach of teaching. The new approach makes them feel better and more positive towards learning science and mathematics. We believe that positive affective experiences emerged during these workshops can be the foundation of a lasting positive attitude (Buff et al., 2011) and that if students attend a number of such workshops, can contribute to maintaining a positive attitude for a long time.

Conclusion

The results of the research conducted as a part of the "Development of scientific and mathematical literacy through active learning" project, show that teaching science and mathematics through the workshops as a form of active class participation, is more acceptable to students than traditional educational forms. The findings also indicate that this type of approach provides better conditions for learning science and mathematics, especially in stimulating students to develop positive attitudes towards the subjects. Based on these findings, it is advisable to include elements of such classroom activities more often in lessons. Naturally, the research presented here opens up numerous new questions, such as the study and comparison of the learning results, acquiring long-term knowledge, interest and motivation for science and mathematics resulting from the traditional, frontal approach in comparison to those resulting from active participation and collaborative teaching which stimulates learning.

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