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COOPERATIVE LEARNING IN TEACHING PHYSICS AND ART IN SECONDARY SCHOOLS

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Abstract. *Teaching physics in primary and secondary schools is realized through classic lecturing in classes of about 30 students, individual examinations, written tests and assignments and laboratory exercises. Knowledge is transferred from teachers to students mostly in its final form, which is not motivating for students or their teachers to develop and construct knowledge actively. A good way to overcome this problem is active teaching/ learning through application of cooperative form of learning, where the aim is that students study through interaction which they enter on the basis of their previous knowledge and skills and to become active creators of their knowledge.*
This study presents a research survey with the aim to establish effects of cooperative learning of physics and music as well as physics and art in secondary schools. The surveys we conducted show that this approach to teaching contributes to a higher level of understanding, better transfer of knowledge, better achievement and also to the inner motivation of both students and teachers. The obtained results indicate that cooperative learning can be applied to students of all ages, for all school subjects and within a large number of themes.

Key words: *physics, cooperative learning, motivation, perception, creativity.*

INTRODUCTION

Current reforms of curricula in primary schools and grammar schools in Serbia announce fewer number of classes of physics. This will have, to a large extent, a negative influence on the content and scope of the teaching process as we know it today. It could provoke lower degree of students' understanding of physical processes and natural phenomena and thus endanger the entirety of their overall knowledge in the field of natural sciences.

These tendencies are indefensible for many reasons and the basic one is that physics constitutes the basis for understanding natural sciences, but also for understanding art and music (optics and acoustics, respectively), and also physical education (statics and dynamics). Physics, as a fundamental science, is extremely important for children's intellectual

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development, as well as for encouraging logical thinking and creation of a clear picture of the world and natural phenomena around us.

Physics curriculum contents are studied at 18 faculties in Serbia, and the application of physics is directly or indirectly unavoidable in electrical engineering, electronics, telecommunications, construction, architecture, traffic, mechanical engineering, technology, medicine, dentistry, veterinary medicine, pharmaceutics, chemistry, biology, agriculture, military skills, mining, geodesy, forestry, meteorology, astronomy, economy, philosophy, sociology, psychology, etc.

The current situation in our educational system is such that two trends can be noticed.

One is related to the reform of vocational schools and the announcement of a reform of grammar schools with fewer physics classes planned. It will have negative consequences on the content and scope of this school subject. A direct consequence certainly will be the absence of integral knowledge students should get.

The other trend is a consequence of the contemporary educational system need to apply physics in various areas and it implies that there is a need for better understanding of scientific terms and their correlation. (Đorđević et al., 2006).

In the European Union countries, a decrease in students' interest for studying physics is noticeable. One of the reasons is that university studies of physics are, objectively speaking, difficult and after graduation, a job one gets is not adequately paid. The traditional way of teaching physics in primary and secondary schools: a teacher mostly speaks while students sit and take notes. Cognitively and motivationally, the engagement of students is weak and conditions for practical skills development are bad. Due to these facts, alternative methods are looked for and cooperative learning is one of them.

A thematic approach to teaching by realizing common classes prepared by teachers of physics together with teachers of art, music and physical education, would replace the ex-cathedra teaching by active participation of students and teachers (cognitively, motivationally, emotionally and socially) (Antić et al., 2000). By application of cooperative learning, students study through the interaction they enter on the basis of their previous knowledge and skills and become active constructors of their knowledge (Ševkušić, 1993).

Associate (cooperative) teaching implies the activity of both students and teachers. Participation of teachers and students in this work cannot be equal – a teacher by far surpasses students due to his/her life experience and maturity. If a teacher introduces students to monthly and weekly plans of work and with instructions how to prepare themselves, students will be motivated and ready for classes (Vilotijević, 2007). In cooperative learning, a student is much more active than in lecturer teaching. Students work together in groups where positive interdependence is encouraged, they actively participate in solving tasks, but they have individual responsibility for success of the group.

Cooperative learning

Cooperative learning is one of the active learning approaches which enables students to study through the interaction they enter on the basis of their previous knowledge and skills and become active constructors of their knowledge (Šišović and Bojović, 2000). It is learning through an asymmetric interaction where the teacher and the students are partners, but the teacher by far surpasses the students due to his/her knowledge, experience and maturity; however, the activity of students is much larger than in traditional teaching. In the last few decades, learning in small groups of students (cooperative learning) was in the focus

of a large number of theoretical and empirical r studies. In schools worldwide, Deutsch's definition of cooperation is used (Deutsch, 1949) as a basis for a technique of this way of learning, and research surveys about the effects of cooperative learning methods have been conducted in Serbia for the last twenty years (Ševkušić, 1995). Cooperative learning provides active construction of knowledge and development of various skills students and teachers have (Slavin, 1987), (Johnson & Johnson, 1978). Cooperative learning increases motivation for work and learning, encourages students to participate actively in a class, to connect and apply previously acquired knowledge, helps and encourages development of higher levels of mental functions, encourages intra-group and inter-group communication and cooperation, develops communication and work on common problems, trains students to notice, set and solve problems, to dialogue and reach decisions (Anfilov, 1966).

The integral approach to common teaching themes is provided by connecting the contents from two areas (Bakovljev, 1970). Students, through joint work on themes from physics and art and physics and music, have the opportunity to apply the ground they have already acquired directly in the areas of art and music and vice versa, the opportunity to learn through interaction within a group and with students from other groups, to make individual and common conclusions and to develop critical thinking.

Cooperative learning encourages and enables exchange of knowledge among students who, as it is known, often have different levels of prior knowledge. This is why the teacher should create a situation for studying where members of the group should learn particular ground and help other members of the group to surmount their part of the task (Ševkušić, 1995). The aim is progress of each student on the basis of the achievement in studying and application of knowledge. Cooperative learning has a task to connect students and teachers to study and achieve satisfactory results in different fields of knowledge. Students study within groups, but they take initial and final tests and get grades individually. By comparing individual and group grades (sum of individual grades of all group members) on initial and final tests, conclusions about whether students have made any progress or not are made (Đorđević at al. 2006), (Milićević at al. 2009).

The basic elements of cooperative learning are (R.T. Johnson, D.W. Johnson, 1978):

- Defining the teaching task and positive interdependence of students, which requires the teacher's preparation and defining a clear and measurable task for a group of students (a teacher emphasizes the concepts which connect the previously acquired ground with a new one, prepares questions to check whether students understood the task and then gives clear and detailed instructions to the students with the emphasis on the significance of cooperation among the students as well as between the teacher and students),
- Individual responsibility (students have a common goal and individual tasks, and each student should contribute to the group work and be responsible for learning of a part of a given task) (Slavin, 1987),
- Upgrading "face to face" interaction, which involves forms of behavior where students mutually encourage and help each other in order to complete the task successfully (the teacher sparks, encourages and praises improving interactions),
- Practicing students' social skills, (the teacher should know which skills students should master and it depends on the nature of the task the group will deal with),
- Evaluation of students' achievement (the teacher monitors the students working on the common task, discusses with the students, evaluates group and individual achievements of the students).

Methodology of research

Two topics from the physics curriculum for the third grade of grammar schools were chosen for a pedagogical experiment:

1. Light in correlation with the topic Independent artistic expression from the art curriculum, and
2. Acoustics in correlation with the topic National schools in romanticism from the music curriculum (Official Gazette of the Republic of Serbia- Educational Gazette of the Republic of Serbia no.3/91)

SUBJECT OF THE RESEARCH

Physics - Art

In secondary schools in Serbia, within the school subject physics, some students study the theme of light in the second and some in the third year, depending on the type of school they attend – grammar school or vocational school (Božin and associates, .2000). The situation is the same with the corresponding contents of art classes (Božin and associates 2000), (Dimić and associates 1972), (Galović, Gostović, 2002).

Two classes of the third year of the languages and social sciences department of Grammar school in Kruševac were chosen as a sample for each group: an experimental group (60 students) and a control group (59 students). Students from the control group studied and had consolidation classes from the theme "light" in a traditional, classical way (teaching contents from physics and art were presented separately, in different classes, without emphasis on connection between the contents of these two school subjects), whereas students from the experimental group studied and had consolidation classes from the same theme by method of cooperative learning (in the further text: traditional learning – approach A, cooperative learning – approach B). The initial test dealing with common themes of these two subjects was conducted in both groups and at the end of the research students took the final test. Classes were realized by teachers of art and physics together.

Physics – Music

In some schools, the theme "acoustics" is presented in physics classes, that is, music classes in the second and in some schools in the third year, depending on the type of school – grammar school or vocational school (Anfilov, 1966), (Božin and associates, 2000), (Dimić and associates 1972).

Two classes of the third year of the languages and social sciences department of Grammar school in Kruševac were chosen as a sample for each group: an experimental group of 60 students and a control group of 58 students. Students from the control group studied and had consolidation classes from the theme "acoustics – the science of sound" in the traditional way, the teacher doing whole class activities, whereas students from the experimental group studied and had consolidation classes of the same theme by methods of cooperative learning (in the further text: traditional learning – approach A, cooperative learning – approach B). The initial test dealing with common themes of these two subjects was also conducted in both classes and in the end students took experimental and final tests. Classes were realized by teachers of music and physics together.

AIM OF THE RESEARCH

The aim of this research is, as it has already been said, to establish the effects of cooperative learning of physics and art as well as physics and music. The good results which were obtained contribute to similar expectations regarding the application of the physics contents and the contents from other subjects.

What was necessary to realize in the above described experiment is the following:

- Mobilization of prior knowledge;
- Independent looking for information related to light, that is, to acoustics;
- Connection of knowledge from the field of light, that is, acoustics with experience from previous school studying;
- Application of knowledge from the field of light, that is, acoustics in other school subjects (art and music) and in everyday life;
- Asking questions, defining problems, discussion and solving problems;
- Students taking their personal attitude in relation to the question: "Why am I studying this?"
- Students' thinking activity;
- Activity, students' interest for reaching the goal; and
- Increase in students' inner motivation for studying.

TASKS OF THE RESEARCH

The research should provide conditions for progress of every student on the basis of achievement in learning and application of the obtained knowledge. This form of work encourages peer interaction and adoption of important "socio-intellectual" skills (Johnson, R.T., & D.W. Johnson 1978):

- Formulation of one's own attitude so that others can understand it,
- Division of roles within a small group,
- Asking questions,
- Noticing obscurities and inconsequence in presentation,
- Careful listening to other persons,
- Repetition of basic ideas of the things presented,
- Giving good feed-back,
- Leading a dialogue,
- Checking whether the others understood us well,
- Showing open-mindedness and sensitivity for opinion of the others,
- Not changing the opinion due to the pressure of majority, but due to the pressure of logical arguments,
- Showing interest for the person you talk to and respect for his/her position regardless of our agreement or disagreement with him/her,
- Making a common, group solution and presentation of the solution to others,
- Taking care of personal responsibility for reaching group aims,
- Development of a sense of belonging, acceptance, care, confidence in other people, mutual connection,
- Development of "social sensibility" and skills and knowledge to fulfill expectations, duties and responsibilities towards the associates,
- Efficient communication and constructive conflict management,

- Engagement of inner motivation,
- Representing experience in various ways.
- Creation of general climate: research, spontaneity, joy of new knowledge,
- Engagement of a complete personality in the process of learning,
- Possibility of evaluation and self-evaluation of knowledge, and
- Praise and tolerance of mistakes.

POPULATION AND SAMPLE

The research involved the third grade grammar school students (two classes of languages and social sciences department, first grade students of School of Electrical Engineering (one class of mechanics department and one class of drivers department) and second grade medical school students (one class of nurse-medical technician department and one class of pharmaceutical technician department) during school years 2007/08, 2008/09 and 2009/10.

This study shows a part of the results of a wider research conducted on the sample of 237 grammar school students during 2007/08 school year.

Organization and the course of research

The research, as it has been already said, included two classes of languages and social sciences department in Grammar School in Kruševac for each group: 60 students (control group) who studied physics-art, that is physics–music by traditional method and 59 students (experimental group) who studied physics–art by cooperative method and 58 students (experimental group) who studied physics–music by cooperative method. Therefore, after presentation of the topics by teachers of physics, art and music according to the curriculum, research-establishing of the effects of these two types of learning were started.

The first class was used for taking the initial test, the second and the third for consolidation of the theme "light", (Galović,V. Gostović,B.,2002), that is, "acoustics – the science of sound" (Anfilov,1966), and the last one for taking the final test, discussion and reaching conclusions.

Students, put into groups randomly, got their tasks related to the teaching ground written on the cards and chosen by representatives of the groups in their second and third classes. This double class had its time dimension so that students, following the instructions from the teacher, talked and agreed among themselves, taught each other, connected and applied knowledge gained in classes of presentation of new ground from physics and art and from physics and music. They exchanged their opinions, teaching materials and teaching aids, reached common conclusions presented later by one member for each group. During presentations by group representatives, other students listened, asked questions, checked the level of understanding of the ground, gave everyday life examples, explained, classified answers and reached conclusions.

In the fourth class, students took the final test from common themes of physics and art and from physics and music as an indicator of their achievements after classes of consolidation of the ground presented by traditional method and by cooperative learning method (Havelka, 1996).

The organization (course) of the class

Plan of realization of pedagogical research (the second and the third class) given in Table 1.

Table 1 Plan of realization of pedagogical research

Planned content of work	Teachers' activity	Students' activity	Time planned in minutes	Methods and forms of work	Way of monitoring students' work	Expected effects
Instructions to students	Divide students in 6 groups, teachers give cards, give instructions for work in each group	Students listen to the teachers, one student from each group chooses a card, students listen to the teacher	15 min	Cooperation teacher -student	Permanent cooperation	
Teachers observe	Teachers observe, help, direct	Students do their assignments in groups	20 min	Cooperation teacher -student	Permanent cooperation	
Teachers invite representatives of each group to present results	Teachers invite representatives of each group to present results	Students present results	25 min	Practice of making surveys, summaries and definition of problems	Public announcement of the problem in question by students	Understanding significance of practical actions which are learnt
Analysis of the results	Analysis of results and reaching conclusions	Analysis of results and reaching conclusions	10 min	Presentation of the basic context, thesis and idea	Exchange, cooperation, complementing	Confrontation, intellectual conflict
Practical application	Teachers listen to the students /observe chosen art paintings	Students play the guitar and the piano / observe chosen art paintings	10 min	Understanding significance of practical actions	Permanent cooperation	Understanding significance of practical actions

INSTRUMENTS OF THE RESEARCH

The initial test

For examination of the effects of learning according to the approaches A and B, the control and experimental groups of students were tested at the beginning and after the process of teaching and learning, that is, the initial level of students' knowledge and the level of knowledge after presentation of the topics were examined.

The initial test physics – art, examined the students' knowledge of light and electromagnetic waves spectrum, wave and geometrical optics, wave characteristics of light, complementary relationships and valere, total reflection, illumination and luminous flux.

The initial test physics – music, examined the students' knowledge of acoustics-sound, origin of sound, sources, characteristics of sound and its connection with musical instruments, then conditions of origin of the sound of different instruments.

Initial testing in both cases lasted one school class each.

The final test

Final testing examined the effects of learning according to the approaches A and B. The testing included the same questions as the initial one, with the aim to check the levels of pre-knowledge and knowledge after application of the approaches A and B with students of the control and experimental groups.

Final testing in both cases lasted one school class each.

Initial and final testing are given as Appendices 1 and 2.

DATA PROCESSING

An analysis and comparison of the initial and final testing results in the control and experimental groups were performed by data processing, as well as the analysis and comparison of the results achieved by students on these occasions.

Physics and art

Table 2 Initial test results for the control group

No. students	2	3	2	1	4	2	5	6	4	2	4	5	6	7	5	2
No. points	3	5	7	9	12	15	18	21	25	28	32	39	40	45	47	49

Table 3 Initial test results for the experimental group

No. students	2	2	3	1	4	6	2	2	3	3	6	6	5	2	3	2	2	5
No. points	3	6	8	12	15	18	20	22	25	28	35	38	40	42	44	45	48	49

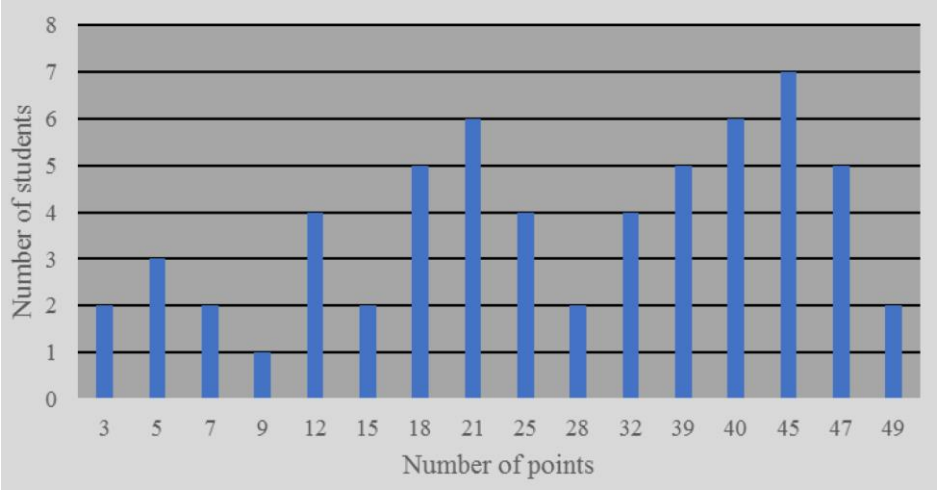

Fig. 1 Distribution of the initial test results for the control group

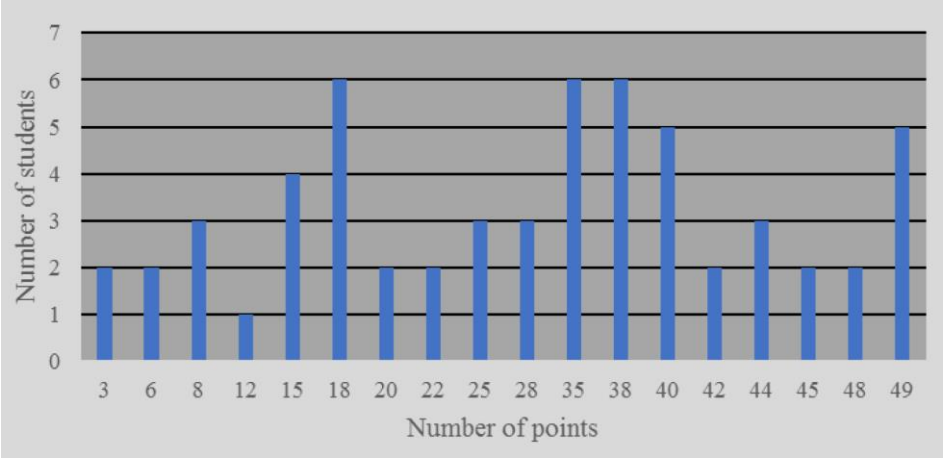

Fig. 2 Distribution of the initial test results for the experimental group

Table 4 The initial test results for the control and experimental groups

Comparative statistics of the initial test for control and experimental groups	Control group	Experimental group
number of students	60	59
minimum	3	3
maximum	49	49
arithmetic mean	28,42	29,66
standard deviation	14,56	14,00
coefficient of variation (%)	51,23	47,21
total percentage of correct answers	56,83	59,32
Difference of means for control and experimental groups	-1,24	
t-test	-0,48	

The initial test results shown in Figure 1 indicate that the control and experimental groups had approximately the same percentage of correct answers to questions from 2 to 9. Deviations in the answers to questions 10-17 point to a slightly better initial knowledge of the students from the experimental group.

Table 5 The final test results for the control group

No. students	3	2	1	2	4	3	5	3	6	3	4	5	2	5	6	1	5
No. points	5	7	10	13	15	16	21	24	25	30	35	40	42	45	46	47	50

Table 6 The final test results for the experimental group

No. students	2	2	3	1	3	4	2	3	2	4	3	2	5	7	5	4	7
No. points	6	8	9	12	15	19	20	23	25	32	35	38	40	44	47	48	50

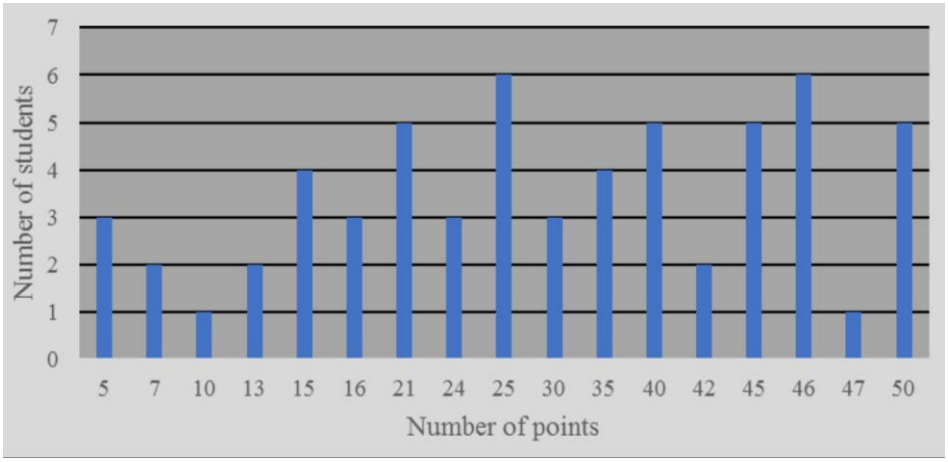

Fig. 3 Distribution of the final test results for the control group

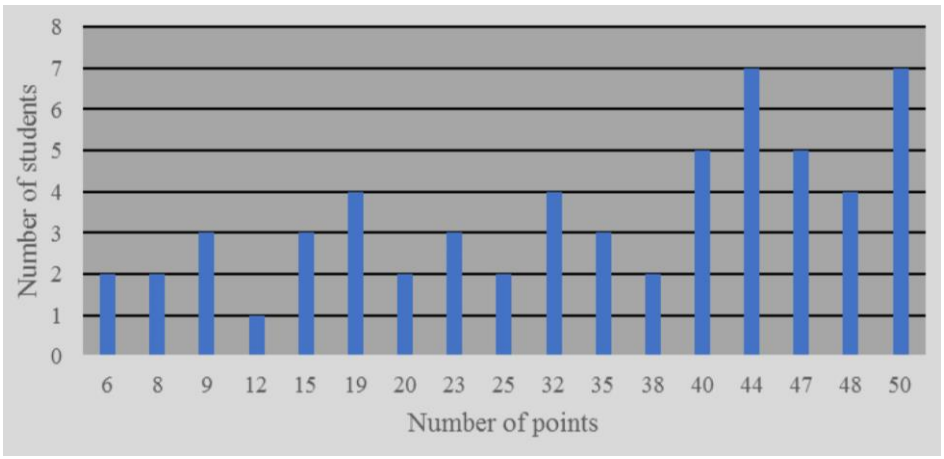

Fig. 4 Distribution of the final test results for the experimental group

Table 7 The final test results for the control and experimental groups

Comparative statistics of the final test for control and experimental groups	Control group	Experimental group
number of students	60	59
minimum	5	6
maximum	50	50
arithmetic mean	30,20	32,90
standard deviation	14,20	14,66
coefficient of variation (%)	47,02	44,55
total percentage of correct answers	60,40	65,80
difference of means for control and experimental groups	-2,70	
t-test	-1,02	

The final testing gave results shown in Figure 2 which indicate that both groups made progress, but with the emphasis on the effect of the experimental group (Galović & Gostović, 2002).

Table 8 The initial and final tests results for the control group

Comparative statistics of the initial and final tests for the control group	The initial test	The final test
number of students	60	60
minimum	3	5
maximum	49	50
arithmetic mean	28,42	30,20
standard deviation	14,56	14,20
coefficient of variation (%)	51,23	47,02
total percentage of correct answers	56,83	60,40
difference of means for control and experimental groups	-1,78	
t-test	-0,68	

Table 9 The initial and final tests results for the experimental group

Comparative statistics of the initial and final tests for the experimental group	The initial test	The final test
number of students	59	59
minimum	3	6
maximum	49	50
arithmetic mean	29,66	32,90
standard deviation	14,00	14,66
coefficient of variation (%)	47,21	44,55
total percentage of correct answers	59,32	65,80
difference of means for control and experimental groups	-3,24	
t-test	-1,23	

It is interesting to compare the initial and final tests results within the groups. Thus, the results which the control group achieved in the initial and final testing (Figure 3), show an evident progress in favor of the final testing, with slight fluctuations from question to question. In the initial testing, the students from this group had on the average 38.29%, and in the final 65.06% of correct answers, which indicates this group's progress of 26.76%.

The results that the experimental group achieved (Figure 4) show an evident progress in favor of the final testing. In the initial testing, the students from this group had on the average 41.88%, and in the final 75.70% of correct answers, which indicates this group's progress of 33.83%.

The control group achieved the best results in the final test for questions 8 and 16, and the experimental group for questions 5, 8, 10, 13, 14, 16 and 17 in the final test, with a higher percentage of correct answers in comparison with the control group.

Physics and music

Table 10 The initial test results for the control group

No. students	1	3	2	2	4	2	3	4	5	3	5	3	5	3	5	1	5	2	2
No. points	3	5	6	8	13	15	18	19	20	22	24	25	29	30	32	34	35	37	39

Table 11 The initial test results for the experimental group

No. students	2	4	1	3	4	6	5	5	3	5	6	4	3	2	3	2
No. points	4	5	7	12	13	18	23	26	28	30	31	33	35	37	39	40

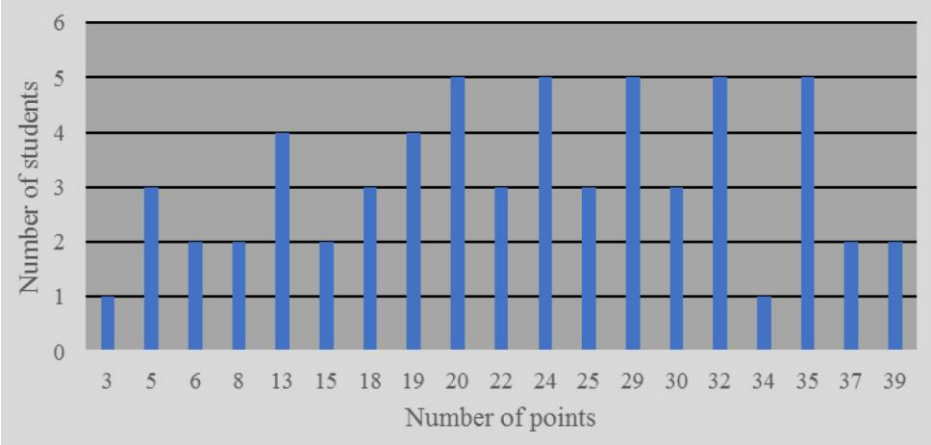

Fig. 5 Distribution of the initial test results for the control group

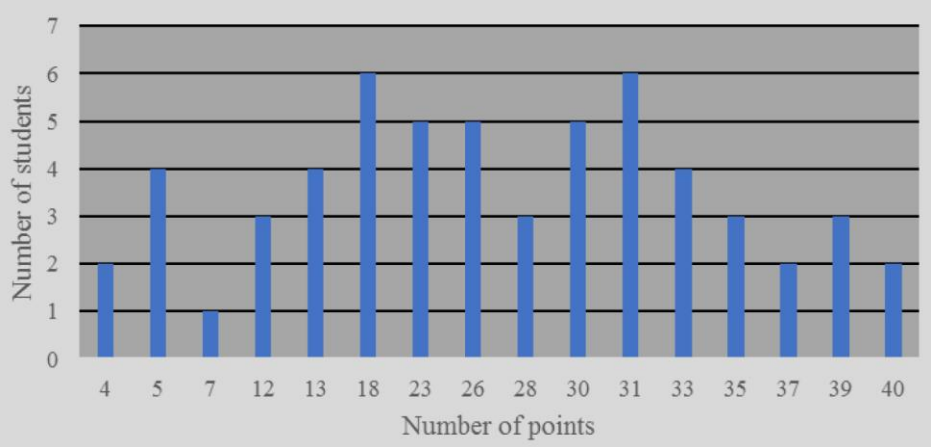

Fig. 6 Distribution of the initial test results for the experimental group

Table 12 The initial test results for the control and experimental group

Comparative statistics of the initial test for control and experimental groups	control group	experimental group
number of students	60	58
minimum	3	4
maximum	39	40
arithmetic mean	22,92	24,21
standard deviation	9,75	10,61
coefficient of variation (%)	42,55	43,85
total percentage of correct answers	50,93	53,79
Difference of means for control and experimental groups	-1,29	
t-test	-0,69	

The initial test results shown in Figure 5 indicate that the control and experimental groups had approximately the same percentage of correct answers to questions from 1 to 4, as well as to questions from 10 to 14. Deviations can be noticed for questions number 5 and 9, which shows a better initial knowledge of the students from the experimental group, whereas answers to questions 6, 7, 8 and 15 indicate a better initial knowledge of the students from the control group.

Table 13 The final test results for the control group

No. students	2	3	2	3	4	4	4	5	5	3	5	6	1	4	4	2	1	2
No. points	4	6	10	12	15	17	21	24	26	28	30	31	32	33	35	37	39	40

Table 14 The final test results for the experimental group

No. students	2	2	1	2	3	2	4	6	4	6	5	4	2	4	3	3	3	2
No. points	4	5	9	12	15	21	23	25	28	30	32	34	35	36	37	38	40	42

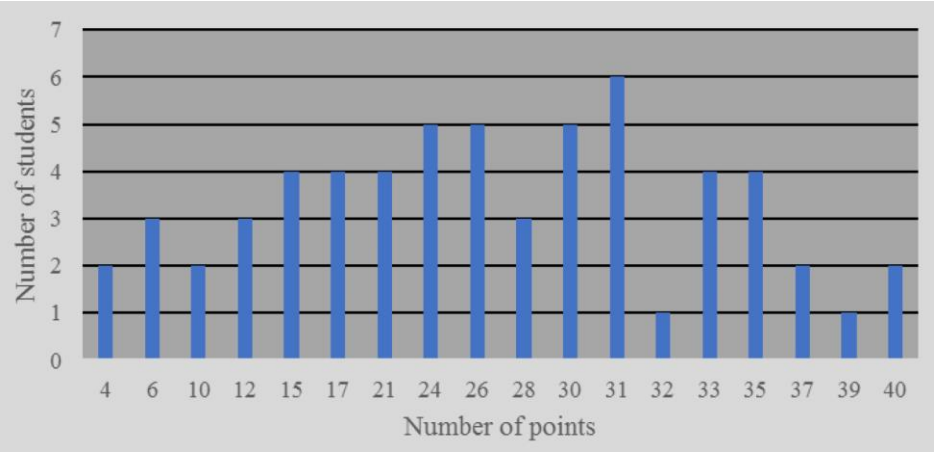

Fig. 7 Distribution of the final test results for the control group

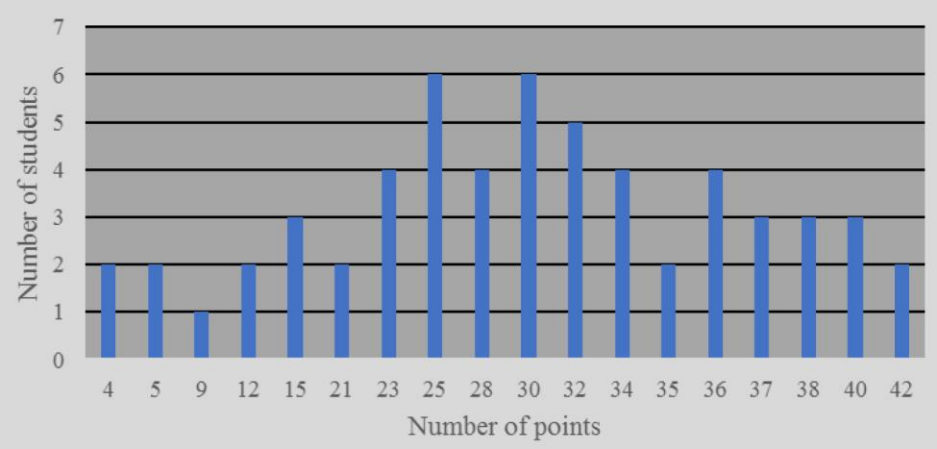

Fig. 8 Distribution of the final test results for the experimental group

Table 15 The final test results for the control and experimental groups

Comparative statistics of the final test for control and experimental groups	control group	experimental group
number of students	60	58
minimum	4	4
maximum	40	42
arithmetic mean	24,35	27,78
standard deviation	9,77	10,09
coefficient of variation (%)	40,13	36,34
total percentage of correct answers	54,11	61,72
difference of means for control and experimental groups	-3,43	
t-test	-1,87	

The final testing gave the results shown in Figure 2 which indicate that both groups made progress, but with the emphasis on the effect of the experimental group (Đorđević et al., 2006).

Table 16 The initial and final tests results for the control group

Comparative statistics of the initial and final tests for the control group	The initial test	The final test
number of students	60	60
minimum	3	4
maximum	39	40
arithmetic mean	22,92	24,35
standard deviation	9,75	9,77
coefficient of variation (%)	42,55	40,13
total percentage of correct answers	50,93	54,11
difference of means for control and experimental groups	-1,43	
t-test	-0,80	

Table 17 The initial and final tests results for the experimental group

Comparative statistics of the initial and final tests for the experimental group	The initial test	The final test
number of students	58	58
minimum	4	4
maximum	40	42
arithmetic mean	24,21	27,78
standard deviation	10,61	10,09
coefficient of variation (%)	43,85	36,34
total percentage of correct answers	53,79	61,72
difference of means for control and experimental groups	-3,57	
t-test	-1,86	

It is interesting to compare the initial and final tests results within the groups. Thus, the results which the control group achieved in the initial and final testing (Figure 3), show an evident progress in favor of the final testing, with smaller or larger fluctuations from question to question. In the initial testing, the students from this class had on the average 32.13%, and in the final 56.67% of correct answers, which indicates this class's progress of 24.54%.

The results that the experimental group achieved (Figure 4) show an evident progress in favor of the final testing. In the initial testing, the students from this group had on the average 33.93%, and in the final 56.47% of correct answers, which indicates this group's progress of 22.54%

The control group achieved the best results in the final test for questions 8, 10, 11, 12 and 15, and the experimental group for questions 8, 11, 12 and 14 in the final test, with approximately the same percentage of correct answers.

CONCLUSION

The results obtained after classes of cooperative teaching of physics and art, that is physics and music, on the basis of active learning, are very good and give us the right to recommend this type of work as one of the basic methods of teaching and presentation of particular modules as a modern way of education of primary and secondary school students. Besides these conclusions made on the basis of numerical indicators, it can also be said that cooperative learning contributes to the better understanding of the curriculum content, development of constructive thinking and increased inner motivation for learning. We have also noticed development of social competences, a better quality of knowledge transfer and faster exchange of information achieved through a better communication and cooperation among students. In a continuous student-teacher interaction, students extend and apply their knowledge very successfully to various fields. This way of teaching makes the teaching process more interesting and provides better quality. This method provides an integral and thematic approach to the curriculum contents common to the above mentioned school subjects and positive students' motivation, which is one of the most significant factors in their progress and education (Slavin, 1987).

Firstly, in this way of acquiring knowledge and consolidation of the already presented grounds, students accept these in a faster and easier way not only through theoretical but

also through practical work. When we come to the issue of teaching physics, contrary to the previously most often abstract way of understanding physics and its laws, students see and accept its applicative character through obvious examples. In this way, even the students who are directed towards social sciences can accept, understand and apply in their closest surroundings the knowledge from the field of physics easily. In that way, students are encouraged, in the scope of their self-initiative thinking, to extend their knowledge to other fields of their interest (economics, pharmaceutics, mining, psychology, geodesy, geography, medicine, etc.).

Art has always existed through scientific and technical discoveries, through the change of the way of perception of the work of art and in that way perception of the world (Leonardo da Vinci, Plato, Durer, Heisenberg and others). From the classical period, through the renaissance and baroque, all the way to the Internet, science and art have always interlaced, overlapped and joined on their way to the new and hybrid.

The recommendation is that physics and art classes can be held in other secondary schools as well (Medical School, School of Electrical Engineering, Chemical Technology School and other schools), as a contribution to the creation of a contemporary worldview.

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APPENDIX 1

Light

School and class: _____

Name and surname: _____

1. Define light.
2. What does wave and what does geometrical optics study?
3. Explain the concept of primary and secondary colors.
4. Explain propagation of light in homogenous and non-homogenous (inhomogeneous) media.
5. Explain polarization of light.
6. Explain interference of light.
7. Explain diffraction of light at an aperture and on diffraction grating.
8. Complementary relationships. Chevreul's circle of colors (impressionism).[1]
9. Laws of reflection and refraction of light.
10. The electromagnetic spectrum.
11. How do atoms create visible light?
12. Valere-sensitivity.[2]
13. Division of a visible part of a light spectrum.
14. Light as a form of energy.
15. Total reflection (Fata Morgana - mirage).
16. Colors in art (Leonardo da Vinci, Goya, Van Gogh).
17. Speed of electromagnetic waves.

APPENDIX2

Sound

School and class: _____

Name and surname: _____

1. What is a sound?
2. List basic characteristics of a sound and explain them.
3. What sources of sound do you know? (list, draw)
4. Draw a tone and a noise; explain the "color" of the sounds of a clarinet, piano, violin.
5. There is complete silence in space. Why?
6. What is the loudest animal in the world?
7. What is the loudest musical instrument in the world made up to now and where is it?
8. Why do different musical instruments sound differently – explain and draw some of them (saxophone, piano)?
9. How is a standing wave created?
10. What are harmonics?
11. Draw a sound wave representing a tone of particular frequency made by:
    a) the piano b) the guitar
    (Show results graphically)
12. How is frequency of n-harmonics in a medium limited on both ends calculated?
13. What musical instruments make a sound in this way?
14. How is frequency of n-harmonics in a medium limited on one end calculated?
15. What musical instruments make a sound in this way?
16. What is sound resonance? Give examples
17. Define subjective strength of a sound.
18. Define objective strength of a sound.

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[1] Chevreul explained how adjacent colors influence each other and that the basic color has its complementary color made of a mixture of the other two (for example Claude Monet's paintings).

[2] Valere in art is a concept used for presenting objects in space by gradation of light, and illumination in physics is presented as luminous flux which falls on a particular surface, that is, a property which decreases with the increase of distance between the surface and the source of light. Valere is a certain degree of light or darkness between the brightest and the darkest surfaces. It is used for explanation of gradation of changes in quantity of light.

KOOPERATIVNO UČENJE U NASTAVI FIZIKE I NASTAVI UMETNOSTI U SREDNJOJ ŠKOLI

Nastava fizike u osnovnim i srednjim školama odvija se putem klasičnih predavanja u odeljenju (oko 30 učenika), individualnog ispitivanja učenika, pismenih vežbi i zadataka, laboratorijskih vežbi. Znanje se prenosi sa nastavnika na učenike uglavnom u finalnom obliku, što ne motiviše učenike i nastavnike da aktivno razvijaju i konstruišu znanja. Dobar način da se ovo prevaziđe je primena kooperativnog učenja, čiji je cilj da učenici uče kroz interakciju u koju ulaze sa bazom prethodnih znanja i umenja i postaju aktivni konstruktori svog znanja.

U ovom radu je prikazano istraživanje čiji je cilj utvrđivanje efekata kooperativnog učenja fizike i muzičke kulture i fizike i likovne kulture u srednjoj školi. Istraživanja koja smo izvršili su pokazala da ovakav pristup nastavi doprinosi višem nivou razumevanja, boljem transferu znanja, većem postignuću i unutrašnjoj motivaciji kako kod učenika tako i kod nastavnika. Naši rezultati ukazuju na to da kooperativno učenje može da se primeni na svim uzrastima učenika, u svim nastavnim predmetima u okviru velikog broja nastavnih tema.

Ključne reči: *nastava fizike, kooperativno učenje, motivacija*.