



JOURNAL
OF BALTIC
SCIENCE
EDUCATION

ISSN 1648-3898 /Print/

ISSN 2538-7138 /Online/

Abstract. *The aim of this research was to examine the effects of a new platform for raising the pre-service chemistry and geography teachers' awareness of cooperation possibilities associated with the planning relevant interdisciplinary lesson. The research featured the participation of 16 students of the Faculty of Chemistry and 28 students of the Faculty of Geography of Belgrade University. Two workshops were conducted within the research. During the first workshop the participants worked in small groups on the tasks which served to strengthen their awareness on the relevant science education. The second workshop comprised the jointly planning the interdisciplinary lessons in groups with members of the pre-service teachers of both subjects. The participants' lesson plans contain goals that can be classified as those relevant for the individual and those relevant for society. Half of the lesson plans contained formulations of goals that can be assessed as relevant for certain professions. The activities planned for the attainment of the stated goals support an interdisciplinary approach, encompass the concepts envisaged by the chemistry and geography curricula, and the activities specific to these two subjects.*

Keywords: *cooperative planning, interdisciplinary lesson, pre-service chemistry teachers, pre-service geography teachers, relevant science education.*

**Dragica D. Trivic, Milanka Džinović,
Vesna D. Milanovic, Ljiljana Živković**
University of Belgrade, Serbia

COOPERATION OF THE PRE-SERVICE CHEMISTRY AND GEOGRAPHY TEACHERS ON AN INTERDISCIPLINARY LESSON PLANNING

**Dragica D. Trivic,
Milanka Džinović,
Vesna D. Milanovic,
Ljiljana Živković**

Introduction

In contemporary society, which is undergoing changes at an increasingly fast pace owing to the development of science and technology, it is important to continually re-examine the necessary professional knowledge and skills of teachers, and from that perspective, the programme of their pre-service training and professional development. The pre-service training of teachers should prepare them to transform various domains of their knowledge with a view to planning a teaching according to learning outcomes from the curriculum, adjusted to the life needs of the learners in a broader social context, and potential professions. Context knowledge is a part of the professional knowledge of teachers (Grossman, 1990, p. 5), which can be an important anchor for decision-making when it comes to adjusting one's teaching under the circumstances of highly intensive social changes and the changing needs of the labour market.

The term of relevance in science education, used by policy-makers, curriculum developers and science education researchers (Stuckey, Hofstein, Mamlok-Naaman, & Eilks, 2013), offers implications for the upgrading pre-service science teachers training. The relevant societal and vocational science education goes beyond single contents and concepts and comprises the development of corresponding skills across disciplines (Belova et al., 2017). According to that, there is a need to find a platform for the pre-service training of teachers that will enable them to improve boundary-crossing skills. These skills could help teachers "to change perspectives, to synthesize knowledge of different disciplines, and to cope with complexity" (Spelt, Biemans, Tobi, Luning, & Mulder, 2009) in order to provide a more comprehensive teaching.

The goals of science education and scientific ideas should be placed in a context that is comprehensible to the students, which can be particularly



challenging in the case of abstract scientific notions (van Dijk & Kattmann, 2007). Science education ought to enable each individual to apply knowledge and skills, reason logically and draw conclusions in connection with personally and socially relevant issues (Eilks & Hofstein, 2015; Rasmussen, 2007), and also to make informed decisions and undertake appropriate activities that contribute to personal welfare, the welfare of society and preservation of the environment (Harlen, 2010; Holbrook, 2005). According to Stuckey et al. (2013) the relevant science education encompasses learners' curiosity and interest, contributes to the development of skills that could be useful for learners in everyday life, as well as to the development of learners' intellectual skills, prepares them for self-determined and responsible life in society, contributes to the development of their competencies to participate in society, especially according to the sustainable development principles, opens youth toward formal career opportunities, and prepares them for further academic or vocational training. Selection of learning topics based on such a model of relevance of science education has led to significant changes in the students' level of motivation and affected the learners' perception of chemistry (Stuckey & Eilks, 2014). Stimulating students to ask questions about topics from the realm of science that are of interest to them increases the attractiveness and relevance of science curricula to students (Baram-Tsabari, Sethi, Bry, & Yarden, 2006; Cakmakci et al., 2012). Pointing out the applicability of that knowledge leads to the students' increased level of interest, which could contribute to better effects of their learning (Demirdogen & Cakmakci, 2014). According to the study, conducted by Siegel and Ranney (2003), it is possible to improve students' attitudes on the relevance of science for their lives by employing the innovative activities.

Through the integration of knowledge and processes of a number of disciplines, and by way of creating teams of teachers and students, an interdisciplinary approach can contribute to improving students' ability of dealing with complex issues and their overall educational experience (Graybill et al., 2006; Jacobson, 2001; Jones, 2009). That is why it is important to ensure the conditions for learning in which the students, in cooperation with their peers, actively construct knowledge, as well as to provide a context which presupposes connecting the contents and specific activities of various science disciplines. According to Spelt et al. (2009), these conditions include, among others, intellectual community of teachers focused on an interdisciplinary approach, "expertise of teachers on interdisciplinarity, consensus on interdisciplinarity, team development, and team teaching". The team-taught settings and the engagement of students in the process of learning through an interdisciplinary approach enable affective and cognitive transformations that contribute to the quality of teaching and better student achievements, and also to a world-view from different perspectives, in keeping with the students' increased ability to participate in this kind of work (Little & Hoel, 2011).

Research has shown that supporting cooperation between teachers on issues in connection with the curriculum, teaching and professional development contributes to improving the students' achievements (Y. L. Goddard, Goddard, & Tschannen-Moran, 2007). Cooperation with their peers, exchange of knowledge and experiences from their teaching practice, brings teachers a higher degree of self-confidence when it comes to trying out new instructional techniques in their teaching practice, which can contribute to the development of innovative practices at the level of the school. Engagement and support within the framework of professional learning communities may lead to increased collective efficiency, and thereby to increased students' achievements (Voelkel & Chrispeels, 2017). Huffman and Kalnin (2003) reported on the positive influence of collaborative inquiry on the professional development of teachers, that this process had improved their knowledge of teaching and the actual teaching practice, and through the increased level of involvement in discussions and solving their school's problems, it had exerted a positive influence of the development of the school generally. Reeves, Hung Pun and Sun Chung (2017) stated that the collaboration of teachers during lesson planning was a significant predictor of students' achievements.

Researches have shown that future teachers express concern on account of the fact that they lack experience in planning and managing teaching activities, the selection of teaching contents, motivating the students to learn, adjusting their teaching to the needs of different students, as well as satisfying the cognitive and social needs of the students (Swennen, Jörg, & Korthagen, 2004; Talanquer, Tomanek, & Novodvorsky, 2007). Encouraging the pre-service teachers, to recognise, within the complex teaching process, the issues that cause concern in them, and the readiness of the educators of pre-service teachers to listen to their students' personal stories, may improve their education and contribute to their further professional development (Nilsson, 2009).

On the basis of the above, it follows that what is necessary in the pre-service training of teachers are situations in which they develop the ability to plan through cooperation relevant teaching in the domain of natural sciences, whose contents have potential to contribute to the development of the students' scientific literacy.



Research Focus

The aim of this research was to examine the effects of a new platform for raising the pre-service chemistry and geography teachers' awareness of the cooperation possibilities associated with the planning relevant interdisciplinary lesson. Our intention was to encourage the pre-service chemistry teachers (PSCT) and the pre-service geography teachers (PSGT) to transform their subject matter knowledge and their knowledge of the context and the curriculum when jointly planning an interdisciplinary lesson, wherein the curricula contents are to be elaborated in contexts relevant for the individual, society and various professions. This could help overcome the problems that beginners have when planning teaching (Swennen et al., 2004; Talanquer et al., 2007), especially when lessons can be considered from the perspective of different disciplines for which teachers are not specialized. The justification for such approach to the pre-service teachers' training arises from the findings of other researches which indicated that there are "a lack of support in schools, and competence of teachers to develop interdisciplinary approaches in the classroom" (Fidalgo-Neto, Lopes, Magalhães, Pierini, & Alves, 2014), and barriers associated with the curriculum organisation, learners' competences to solve interdisciplinary problems and teachers competences to support learners in this direction (Stentoft, 2017).

In accordance with the aim that had been set, the following research questions were defined:

How does raising the pre-service chemistry and geography teachers' awareness of relevant science education influence their ability to plan an interdisciplinary lesson?

How does the cooperation among the pre-service chemistry and geography teachers influence their ability to plan an interdisciplinary lesson?

Research Methodology

General Background

A case study research design was employed in order to understand a specific phenomenon related to the pre-service chemistry and geography teachers collaboratively planning an interdisciplinary lesson, based on their awareness of meaning and impact of the relevant science education. Both qualitative and quantitative data, which document the pre-service teachers experience in the specific setting, were collected in this case study. The research consisted of two main parts and duration of each part was 180 minutes. The students and staff of two faculties of the University of Belgrade were involved in the research.

Sample

The research featured the participation of 16 PSCT of the Faculty of Chemistry and 28 PSGT of the Faculty of Geography. These are separate faculties within the University of Belgrade, and the education of PSCT and PSGT is carried out independently. All participants in the research were students of the fourth year of study. The curricula for training the PSCT and PSGT at both faculties prepare the candidates completely for teaching chemistry or geography in the second cycle of primary school (attending by students from 11 to 14 years old) and secondary school (attending by students from 15 to 18 years old). Among secondary schools, there are general secondary schools (grammar schools), vocational schools and art schools.

The applied activities within the framework of this research were additional to the regular teachers training at both faculties, through which we strove to enhance, through the meetings of the staff and students of the two faculties, their awareness of cooperation possibilities.

Throughout the research, the ethical guidelines for research within education (Cohen, Manion, & Morrison, 2009) were followed. The students' participation in the research was on a voluntary basis, and their results did not have any influence on their marks in their final exams.

Procedure and Instruments

Each of two parts of the research comprised a workshop, in the course of which the students fulfilled tasks working in small groups (Table 1), following which they presented the results of their group work, discussed them and considered the main implications for their future practice. In the first part, the PSCT and PSGT worked on the



given tasks independently, whereas in the second part they worked together, within the groups made up of the participants from both faculties. In the first part, the tasks served to strengthen the participants' awareness on relevant science education, while in the second part, based on the previous work, the participants collaboratively planned an interdisciplinary lesson.

Before starting on the second part, four topics were selected from among those previously proposed by the PSCT and PSGT, those estimated by the staff members of both faculties to be in keeping with the curricula of primary and secondary school education and suitable for being dealt with through an interdisciplinary approach. There were the following topics: 1. The formation of the soil, its properties and composition; 2. The fossil sources of energy - coal, oil and natural gas; 3. Erosion of limestone rocks; 4. Pollutants in the air and climate changes. Two different groups were assigned the same topic. The reason for doing so was to give the participants the opportunity, during the phase of presenting and discussing lesson plans, to compare different possibilities of dealing with the same topic using an interdisciplinary approach.

After each part the participants filled in the questionnaires individually.

Table 1. The activities plan.

Step	Activities: PSCT	Activities: PSGT
Workshop 1		
Part I lasting 180 minutes	Task 1. Propose questions to which answers may be arrived at in cooperation between chemists and geographers.	Task 1. Propose questions to which answers may be arrived at in cooperation between chemists and geographers.
	Task 2. Evaluate the relevance of your questions from the perspective of general education serving the needs of: <ul style="list-style-type: none"> • the individual in everyday life, • contemporary society, • various professions. Elaborate on your questions, so that the answers to them better reflect the requisite knowledge for: <ul style="list-style-type: none"> • the everyday life of the individual, • life in contemporary society, • various professions. 	Task 2. Evaluate the relevance of your questions from the perspective of general education serving the needs of: <ul style="list-style-type: none"> • the individual in everyday life, • contemporary society, • various professions. Elaborate on your questions, so that the answers to them better reflect the requisite knowledge for: <ul style="list-style-type: none"> • the everyday life of the individual, • life in contemporary society, • various professions.
	Task 3. Find lessons in the chemistry curricula for primary school and grammar school, within the framework of which the questions could be elaborated, and which correspond to the aims of learning those lessons: <ul style="list-style-type: none"> • according to the chemistry curriculum for primary school, • according to the chemistry curriculum for grammar school. 	Task 3. Find lessons in the geography curricula for primary school and grammar school, within the framework of which the questions could be elaborated, and which correspond to the aims of learning those lessons: <ul style="list-style-type: none"> • according to the geography curriculum for primary school, • according to the geography curriculum for grammar school.
Questionnaire 1		Questionnaire 1
Workshop 2		
Part II lasting 180 minutes	Forming eight groups made up of the PSCT and the PSGT and jointly preparing a lesson plan (two different groups are assigned the same topic).	
	Presenting lesson plans. Discussing the plans from the perspective of the set aims and planned activities. Giving proposals for improving the plans by other participants, assistant lecturers in the subject and, finally, the professors of the given subjects.	
Questionnaire 2		

Two questionnaires were applied for the purpose of this research. Through the questionnaire 1 with six open-type tasks (Appendix 1), we explored which topics from the chemistry and geography curricula, estimated as relevant for the individual, society and various professions, the participants would elaborate interdisciplinary through mutual cooperation.

Through the questionnaire 2, we explored views of the PSCT and PSGT on the advantages and drawbacks when it comes to applying an interdisciplinary approach, as well as their views on the manner of work within two workshops. The questionnaire consisted of six open-type questions and of 10 questions featuring a five-point Likert scale (Appendix 2).

The validity of the questionnaires in view of the aims and the research questions was evaluated by two uni-



versity experts who were not involved in the research, but they are involved in the teacher education.

The worksheets and the questionnaires were implemented in students' mother tongue.

Data Analysis

The students' replies to open-type questions that they gave in the questionnaires were analysed and classified in terms of categories, to which descriptive statistics was applied. The qualitative coding process involved grouping the responses into categories and seeking evidence from the data for each code category (Creswell, 2009). Codes were named by using the exact words of participants or by using names created by the researcher that appropriately describe the PSCT and PSGT answers. The answers given by the PSCT and PSGT in worksheets were also classified in terms of categories. The lesson plans that the students produced within the second workshop were analysed by identifying within each lesson plan the goals that could be considered relevant for the individual, society or various professions. Following that we monitored whether the planned activities in the classroom led to the achievement of those goals.

The following reliability procedures according to Gibbs's (2007) suggestions were applied: (i) constantly comparing data with the codes in order to make sure that there is not a shift in the meaning of the codes during the process of coding; (ii) coordination of communication among the coders (i.e. authors of the paper), by sharing the analysis; (iii) cross-checking the coding process by comparing independently derived results.

According to the recommendation of Creswell (2009) the *member checking* was applied to determine the accuracy of the qualitative findings which comprised the participants' estimation whether the final report accurately represents their views, discussions and lesson plans.

Research Results

Results Pertinent to the Questionnaire 1

The open-type tasks contained in the questionnaire 1, and the categories and frequencies of answers of the PSCT and PSGT are presented in Table 2.

Table 2. The answers of the PSCT and PSGT in the questionnaire 1 (a total number of the PSCT $N = 16$; a total number of the PSGT $N = 28$).

Tasks	The PSCT answers				The PSGT answers			
	Categories of answers	<i>N</i>	%	Categories of answers	<i>N</i>	%		
Define topics that you would deal with together with geography /chemistry teachers in primary school which are relevant for the everyday life of the individual	Water	12	75.0	Hydrosphere	20	71.4		
	Pollution and protection of the environment	6	37.5	Atmosphere	19	67.9		
	Pure substances and mixtures	5	31.2	The soil and erosion	12	42.9		
	Metals	3	18.8	Pollution and protection of the environment	4	14.3		
	Non-metals	3	18.8	Chemical elements	4	14.3		
	Hydrocarbons (oil, natural gas)	2	12.5	Lithosphere	3	10.7		
	Acids, bases and salts	2	12.5	Mining and energy	2	7.1		
Define topics that you would deal with together with geography /chemistry teachers in primary school which are relevant for society				Biosphere	2	7.1		
				Chemical industry	1	3.6		
	Pollution and protection of the environment	13	81.2	Pollution and protection of the environment	11	39.3		
	Hydrocarbons (oil, natural gas)	5	31.2	Hydrosphere	10	35.7		
	Metals	5	31.2	Atmosphere	8	28.6		
	Non-metals	4	25.0	The soil and erosion	6	21.4		
	Pure substances and mixtures	3	18.8	Chemical industry	4	14.3		
Water	2	12.5	Chemical elements	2	7.1			
Acids, bases and salts	2	12.5						
The soil	1	6.2						



Tasks	The PSCT answers				The PSGT answers			
	Categories of answers	N	%	Categories of answers	N	%		
Define topics that you would deal with together with geography /chemistry teachers in primary school which are relevant for various professions	Hydrocarbons (oil, natural gas)	8	50.0	Biosphere	11	39.3		
	Pollution and protection of the environment	7	43.8	Pollution and protection of the environment	6	21.4		
	Metals	4	25.0	The soil and erosion	4	14.3		
	Non-metals	4	25.0	Chemical industry	4	14.3		
	Pure substances and mixtures	3	18.8	Hydrosphere	2	7.1		
	Acids, bases and salts	2	12.5	Chemical elements	2	7.1		
	Water	1	6.2	Atmosphere	1	3.6		
	The soil	1	6.2	Mining and energy	1	3.6		
Define topics that you would deal with together with geography /chemistry teachers in secondary school which are relevant for the everyday life of the individual				Lithosphere	1	3.6		
	Pollution and protection of the environment	11	68.8	Lithosphere	10	35.7		
	Pure substances and mixtures	6	37.5	Atmosphere	9	32.1		
	Water	5	31.2	Hydrosphere	8	28.6		
	Acids, bases and salts	5	31.2	The soil and erosion	7	25.0		
	Metals	3	18.8	Pollution and protection of the environment	3	10.7		
	Hydrocarbons (oil, natural gas)	2	12.5	GMO	3	10.7		
	The soil	2	12.5	Mining and energy	2	7.1		
	Lithosphere	2	12.5	Chemical elements	2	7.1		
	Non-metals	1	6.2	Chemical industry	2	7.1		
Define topics that you would deal with together with geography /chemistry teachers in secondary school which are relevant for society				Agriculture	2	7.1		
	Pollution and protection of the environment	10	62.5	Pollution and protection of the environment	12	42.9		
	Pure substances and mixtures	6	37.5	Lithosphere	6	21.4		
	Metals	5	31.2	Atmosphere	4	14.3		
	Hydrocarbons (oil, natural gas)	3	18.8	Chemical elements	2	7.1		
	Acids, bases and salts	2	12.5	Hydrocarbons (oil, natural gas)	2	7.1		
	Water	1	6.2	The soil and erosion	1	3.6		
	Polymers	1	6.2	Hydrosphere	1	3.6		
	The soil	1	6.2	Chemical industry	1	3.6		
	Lithosphere	1	6.2					
Define topics that you would deal with together with geography /chemistry teachers in secondary school which are relevant for various professions	Non-metals	1	6.2	Mining and energy	8	28.6		
	Pollution and protection of the environment	6	37.5	Geodesy and civil engineering	6	21.4		
	Hydrocarbons (oil, natural gas)	4	25.0	Chemical elements	3	10.7		
	Nitrogen compounds (fertilizers)	4	25.0	Atmosphere	3	10.7		
	Acids, bases and salts	4	25.0	Hydrosphere	2	7.1		
	Water	3	18.8	Lithosphere	1	3.6		
	Pure substances and mixtures	2	12.5	The soil and erosion	1	3.6		
	Metals	2	12.5	Hydrocarbons (oil, natural gas)	1	3.6		
	Non-metals	2	12.5	Chemical industry	1	3.6		
	Biotechnology	1	6.2	Tourism	1	3.6		

Results Pertinent to the Questionnaire 2

The categories of answers of the students from both groups related to the open-type questions contained in the questionnaire 2 are presented in Table 3.



Table 3. The categories of answers of the PSCT (a total number $N = 16$) and PSGT (a total number $N = 28$) on the open-type questions in the questionnaire 2.

Variables	Answers by category	PSCT		PSGT	
		N	%	N	%
Advantages of an interdisciplinary approach in teaching	Connecting the contents of more than one subject.	10	62.5	16	57.1
	Connecting scientific concepts with everyday life and application of knowledge.	4	25.0	-	-
	Connecting course contents with previously acquired knowledge.	2	12.5	2	7.1
	Condensing course material.	1	6.2	-	-
	Team work and communication.	4	25.0	11	39.3
	The students being active and acquiring the course material more easily.	-	-	10	35.7
Obstacles to an interdisciplinary approach to teaching	The course material is too large – a change of the curriculum is necessary.	4	25.0	4	14.3
	Lack of interest on the part of teachers and unwillingness to cooperate.	7	43.8	8	28.6
	Work conditions (adjusting the timetables for teaching different subjects, in terms of time and space).	4	25.0	9	32.1
	A sharp dividing line between sciences when they are studied within the framework of separate subjects.	-	-	2	7.1
	There are no obstacles.	4	25.0	7	25.0
Necessary preconditions for applying an interdisciplinary approach in teaching	Teachers' readiness to cooperate and good communication.	4	25.0	14	50.0
	Teacher training within the framework of a programme of professional development.	4	25.0	4	14.3
	The changes of the curricula are necessary.	3	18.8	1	3.6
	Work conditions (providing teaching aids).	-	-	15	53.6
	That there is a possibility of correlating the teaching of different subjects.	-	-	7	25.0
Changed view about an interdisciplinary approach in teaching	Yes. Along with this answer, the students stated that, through the workshop, they realised the existence of the possibility for an interdisciplinary approach to dealing with the course contents of geography and chemistry, that such lessons could be more interesting, and the knowledge acquired this way longer lasting.	13	81.2	25	89.3
	No. Along with this answer, the students stated that even before this they had seen the possibility for an interdisciplinary approach to teaching, and that the workshop provided them with an additional confirmation of this.	3	18.8	3	10.7
Good sides of the workshops	Cooperation with colleagues, different experiences and group work.	16	100.0	27	96.4
	Reporting and the possibility of reviewing the results of the other groups.	6	37.5	5	17.9
Weak sides of the workshops	The short time available for thinking up a lesson plan featuring an interdisciplinary approach.	5	31.2	2	7.1
	Unwillingness to accept the opinions of others.	3	18.8	1	3.6
	The lack of interest for team work on the part of some colleagues.	3	18.8	1	3.6
	The workshop lasted too long.	-	-	2	7.1
	What was missing was the practical part (laboratory and field work).	-	-	2	7.1
	No objections.	8	50.0	21	75.0

In Table 4, the answers by frequency – the degree of correspondence of the statements given by the participants, expressed by means of a five-point Likert scale in the questionnaire 2 are presented.



Table 4. The degree of agreement of the PSCT and the PSGT with the statements below, expressed by means of a five-point Likert scale*

Statements	N (%) of the PSCT (a total number N=16)					N (%) of the PSGT (a total number N=28)				
	1	2	3	4	5	1	2	3	4	5
An interdisciplinary approach to course contents may improve the scientific literacy of students.	-	-	-	4 25.0%	12 75.0%	-	-	1 3.6%	11 39.3%	16 57.1%
An interdisciplinary approach always gives better results when it comes to dealing with terms from the perspective of one scientific discipline.	-	-	3 18.8%	3 18.8%	10 62.5%	-	1 3.6%	4 14.3%	15 53.6%	8 28.6%
An interdisciplinary approach improves the knowledge which is relevant for the everyday life of the individual.	-	-	-	5 31.2%	11 68.8%	-	-	10 35.7%	12 42.8%	6 21.4%
An interdisciplinary approach improves the knowledge which is relevant for life in contemporary society.	-	-	-	8 50.0%	8 50.0%	-	-	9 32.1%	12 42.8%	7 25.0%
An interdisciplinary approach to the education of teachers improves the development of their teaching competences.	-	-	-	8 50.0%	8 50.0%	-	-	6 21.4%	12 42.8%	10 35.7%
Each part of the chemistry and geography curriculum can be dealt with by means of a simultaneous approach from the perspectives of those two sciences.	-	3 18.8%	13 81.2%	-	-	-	13 46.4%	12 42.8%	1 3.6%	2 7.1%
What is required for the realisation of teaching through an interdisciplinary approach is that special preconditions be fulfilled.	6 37.5%	7 43.8%	2 12.5%	1 6.2%	-	-	9 32.1%	4 14.3%	11 39.3%	4 14.3%
My university-level education so far has prepared me to realise various roles of a chemistry/geography teacher.	2 12.5%	1 6.2%	5 31.2%	7 43.8%	1 6.2%	-	5 17.9%	13 46.4%	10 35.7%	-
Cooperation with other students, future teachers of other subjects, contributes to improving my teaching competences.	-	-	-	9 56.2%	7 43.8%	-	-	5 17.9%	13 46.4%	10 35.7%
In my future teaching practice, I shall strive to plan and realise my teaching through cooperation with teachers of other subjects.	-	-	-	4 25.0%	12 75.0%	-	-	8 28.6%	13 46.4%	7 25.0%

* 1 – Strongly disagree, 2 – Disagree, 3 – Neither agree nor disagree, 4 – Agree, 5 – Strongly agree



Discussion

During the first workshop, the PSCT and PSGT worked independently of one another, but the questions that they produced refer to similar areas, that is, they belong to similar categories. These questions cross boundaries *within* the topics traditionally studied by the chemistry and geography curricula. According to Newell (2007), the order of complexity of such questions is lower than when the problem crosses boundaries *between* areas traditionally studied by different disciplines. However, the elaboration of questions produced by the PSCT and PSGT still requires the full interdisciplinary process.

Results Pertinent to the Questionnaire 1

The topic of water is most frequently estimated as relevant for the individual by the PSCT that they would elaborate in cooperation with geography teachers, in primary school, while in secondary school it would be pollution and protection of the environment. Dealing with the topic of pollution and protection of the environment in cooperation with geography teachers in both primary and secondary school was estimated to be relevant for society by most of the PSCT. The most frequent topics proposed for primary school as being relevant for various professions are hydrocarbons, pollution and protection of the environment, whereas those most frequently proposed for secondary school are pollution and protection of the environment.

On the basis of the answers given by the PSGT, most of them would cooperate with chemistry teachers in primary school dealing with the topics of the hydrosphere and the atmosphere, on account of the fact that they are relevant for the individual. This is in keeping with the answers of most of the PSCT, who would cooperate with geography teachers dealing with the topic of water, which they consider to be relevant for the individual. Most of the PSGT would cooperate with chemistry teachers, in primary as well as secondary school, dealing with the topic of pollution and protection of the environment, as being relevant for society. In that respect, they agree with the PSCT. Apart from this, in terms of how frequently it was mentioned in the participants' answers as a topic relevant for society, one which can be dealt with in primary school, the hydrosphere stands out. As regards the most frequently mentioned topic to be dealt with in cooperation with chemistry teachers in primary school, as being relevant for various professions, that of the biosphere stands out.

Among the secondary school topics relevant for the individual, that of the lithosphere (the inner structure of the Earth and the composition of rocks) stands out in terms of the frequency of its being mentioned in the students' answers, followed by the atmosphere and the hydrosphere. The PSGT most often selected mining and energy as the secondary school topics relevant for various professions.

The Main Characteristics of the Lesson Plans

The analysis of the participants' lesson plans encompassed an assessment of whether their goals had been defined so that they reflected the relevance of the topics for the individual, society and various professions, and whether the planned activities enabled the realisation of such goals.

All of the eight lesson plans contain goals that can be classified as those relevant for the individual and those relevant for society, based on the model of relevance referred to by Stuckey et al. (2013). Among the goals assessed to be relevant for the individual were also those pertaining to academic knowledge as part of scientific literacy, comprising the pupils' ability to recognize scientific concepts – *nominal literacy*, to define some key concepts – *functional literacy* and to explain phenomena based on the understanding of scientific concepts – *conceptual literacy* (Bybee, 1997; Shwartz, Ben-Zvi, & Hofstein, 2006). Half of the lesson plans contained formulations of goals that can be assessed as relevant for certain professions.

The activities planned with a view to realising the goals, stated by the participants, support an interdisciplinary approach and comprise dealing with the given topics from the perspectives of chemistry and geography. This includes the concepts envisaged by the curricula of both subjects and activities specific to these two subjects. As an illustration of the specific activities from the participants' lesson plans, the following examples can serve:

- Experimental investigation of the properties of various soil samples, samples of oil and coal.
- Performing an experiment wherein carbon dioxide is introduced into a solution of calcium hydroxide, producing precipitate of calcium carbonate, describing the physical properties of calcium carbonate (its solubility in water, colour), producing calcium hydrogen carbonate (precipitate disappears), writing the



- chemical equations of two reactions; connecting the experiments with the changes of limestone rocks.
- Observing a demonstration of the reaction between calcium carbonate and hydrochloric acid, describing the change that occurs in this experiment and explaining the properties of the reactants and the change that occurred.
- Marking locations of types of soil and limestone rocks, and deposits of oil, coal and natural gas, on a geographic map.
- Conducting stoichiometric calculations of the mass percentage of carbon in various types of coal.

According to the participants' lesson plans, pupils should use different sources of information: the presentations of the chemistry and geography teachers, texts, pictures, the Internet. In three cases group work was planned with the aim to enable pupils to construct new knowledge through cooperation. According to the Nikitina's (2006) distinguishing three basic approaches to an interdisciplinary curriculum, the participants' lesson plans involve two strategies: *a contextualizing* and *a conceptualizing*. It means that they embedded the curricula contents of two subjects into the contexts associated with the learners' experiences from real life, as well as contexts related to society, and in some cases to professions. Also, they identified the core concepts that are central to two disciplines and established the connections among them.

Results Pertinent to the Questionnaire 2

Most of the PSCT and the PSGT stated that linking the contents of different subjects was an advantage of an interdisciplinary approach. In the second place in terms of the frequency of their being mentioned in the students' answers are team work and good communication as the advantages of an interdisciplinary approach. In addition to this, the PSGT pointed out the pupils' activities and their easier acquisition of the course material, while the PSCT pointed out connecting scientific concepts with everyday life. As regards the frequency of the participants' answers concerning the obstacles to the application of an interdisciplinary approach in the teaching of chemistry and geography, the respondents in both groups singled out lack of interest on the part of teachers and their unwillingness to cooperate, the work conditions, in terms of adjusting the timetable of lessons of different subjects, spatially as well as temporally. Both groups of participants singled out a greater degree of willingness for cooperation on the part of teachers as a necessary precondition for applying an interdisciplinary approach in primary and secondary school. The PSCT pointed out that what was necessary was teacher training through professional development programmes, as well as introducing changes to the curricula, while the PSGT singled out, to a greater extent, the conditions pertaining to the necessary equipment (teaching aids).

The answers of the PSCT and PSGT presented through a five-point Likert scale, show that they agree to a great degree (in terms of *agree* and *strongly agree*) that an interdisciplinary approach can improve the scientific literacy of students and increase the level of knowledge relevant for the individual and society (the view expressed by around one third of the PSGT concerning the relevance for the individual and society was *neither agree nor disagree*). The PSCT manifested a high degree of agreement concerning the view that such an approach within the framework of the education of teachers improves their teaching competences, as does cooperation with students of other subjects, and that they would strive, as part of their forthcoming practice, to cooperate with teachers of other subjects. Pertaining to these views as well, less than one third of the PSGT gave *neither agree nor disagree* as their answer. Compared to the PSCT, a somewhat higher number of the PSGT expressed doubt concerning the view that such an approach always gives better results than dealing with scientific concepts from the perspective of a single discipline. Low- and medium-level agreement dominated when it came to the answers of both groups of participants concerning the claim that all chemistry and geography contents can be dealt with through an interdisciplinary approach, which is indicative of a critical approach to this issue. The PSCT and PSGT differ in their views when it comes to the question of whether special preconditions need to be fulfilled for the purpose of the realisation of teaching through an interdisciplinary approach. The dominant view among the PSCT is that no special conditions are required, whereas the opposite view predominates among the PSGT. Most of the PSCT estimate that their university education so far has, for the most part, prepared them to realise diverse roles, but there are also those among them who do not consider themselves prepared for that, or only partially prepared. Most of the PSGT estimate that their university education has partially or mostly prepared them for diverse teaching roles.

According to the answer of PSGT on the weak sides of the workshops (Table 3), more positive attitudes of the PSCT, presented through a five-point Likert scale, in comparison with the PSGT (Table 4), could not be associated with the influence of the workshops. An analysis of previous education and experience of these two groups of



students would be helpful to identify the reasons for their different attitudes, but this goes beyond the scope of this research. The focus in this case study was on the activities and processes associated with relevance in science education and an interdisciplinary planning in two groups of the pre-service teachers.

Conclusions

Within this research we intended to better understand a specific phenomenon related to the pre-service chemistry and geography teachers collaboratively planning an interdisciplinary lesson, after intervention on the improvement of their awareness of meaning and impact of the relevant science education. Also, we intended to increase their awareness about the importance of cooperation with colleagues from different subjects in order to provide learners with relevant and a more comprehensive understanding of the subject under study. It could be important for pre-service teachers, initially educated for teaching certain subject, to notice what they can do in the situation when a lesson can be considered from the perspective of discipline for which they are not specialized. Cooperation with other colleagues in lesson planning could help overcome the problem of deficit knowledge from a nonspecialized subject.

It has been found that all of the eight lesson plans created within the second workshop contain goals relevant for the individual and society. In the case of half of these lesson plans, the goals that were formulated can be assessed as relevant for certain professions. Both workshops show that the relevance for various professions is the least known for the pre-service teachers of both subjects. It could be due to their limited knowledge or experience about different professions.

The participants applied the contextualizing and conceptualizing strategy in order to plan an interdisciplinary lesson. The activities planned for the realisation of the stated goals support an interdisciplinary approach and encompass the concepts envisaged by the chemistry and geography curricula, as well as activities specific to these two subjects. This confirmed that the pre-service teachers of both subjects contributed with their previous knowledge and experience to the process of planning the interdisciplinary lessons.

The pre-service teachers' answers confirmed that the intervention on raising their awareness of relevant science education and cooperation possibilities in an interdisciplinary lesson planning enabled them to consider advantages and obstacles of this kind of teaching. The linking of the contents of different disciplines is what the students from both faculties singled out as the advantage of this kind of work, pointing out its potential for improving teachers' competences and the scientific literacy of students, relevant for the individual and society. The students from both groups are of the opinion that not all course contents can be dealt with in this way, but most of them express their readiness to plan and realise their teaching through an interdisciplinary approach, cooperating with teachers of other subjects.

Limitations

The limitation of this research is related to the pre-service teachers' understanding in connection with the discipline to which another subject belongs. Another limitation is connected with the participants' previous experience and expertise to determine what is relevant and transferable to an array of different societal outlets. A further limitation is associated with small samples of the pre-service teachers of two subjects. However, the results of this research could be a starting point for further researches about cooperation possibilities of different groups of pre-service teachers on relevant interdisciplinary teaching.

Acknowledgements

This research is the result of work on the project "The Theory and Practice of Science in Society: Multidisciplinary, Educational and Intergenerational Perspectives", No. 179048, the realization of which is financed by the Ministry of Education, Science and Technological Development of the Republic of Serbia.

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Appendix 1**Questionnaire 1 for the pre-service chemistry teachers (PSCT)**

No.	Tasks
1	Define topics that you would deal with together with geography teachers in primary school which are relevant for the everyday life of the individual.
2	Define topics that you would deal with together with geography teachers in primary school which are relevant for society.
3	Define topics that you would deal with together with geography teachers in primary school which are relevant for various professions.
4	Define topics that you would deal with together with geography teachers in secondary school which are relevant for the everyday life of the individual.
5	Define topics that you would deal with together with geography teachers in secondary school which are relevant for society.
6	Define topics that you would deal with together with geography teachers in secondary school which are relevant for various professions.

Questionnaire 1 for the pre-service geography teachers (PSGT)

No.	Tasks
1	Define the topics that you would deal with together with chemistry teachers in primary school which are relevant for the everyday life of the individual.
2	Define the topics that you would deal with together with chemistry teachers in primary school which are relevant for society.
3	Define the topics that you would deal with together with chemistry teachers in primary school which are relevant for various professions.
4	Define the topics that you would deal with together with chemistry teachers in secondary school which are relevant for the everyday life of the individual.
5	Define the topics that you would deal with together with chemistry teachers in secondary school which are relevant for society.
6	Define the topics that you would deal with together with chemistry teachers in secondary school which are relevant for various professions.

Appendix 2**Questionnaire 2**

No.	Questions
1	What do you recognise as the advantages of an interdisciplinary approach in teaching?
2	What do you recognise as obstacles to an interdisciplinary approach to teaching?
3	What do you consider to be the necessary preconditions for applying an interdisciplinary approach in teaching?
4	Has your view of the possibility of dealing with course material from chemistry and geography through an interdisciplinary approach changed?
5	What did you like about the workshops that were realised?
6	What did you not like about the workshops that were realised?



- 7 Rate your agreement with the following statements on a 5-point scale:
(1 - Strongly disagree; 2 - Disagree; 3 - Neither agree nor disagree; 4 - Strongly agree; 5 - Agree)

Statements	1	2	3	4	5
a An interdisciplinary approach to course contents may improve the scientific literacy of students.					
b An interdisciplinary approach always gives better results when it comes to dealing with terms from the perspective of one scientific discipline.					
c An interdisciplinary approach improves the knowledge which is relevant for the everyday life of the individual.					
d An interdisciplinary approach improves the knowledge which is relevant for life in contemporary society.					
e An interdisciplinary approach to the education of teachers improves the development of their teaching competences.					
f Each part of the chemistry and geography curriculum can be dealt with by means of a simultaneous approach from the perspectives of those two sciences.					
g What is required for the realisation of teaching through an interdisciplinary approach is that special preconditions be fulfilled.					
h My university-level education so far has prepared me to realise various roles of a chemistry/geography teacher.					
i Cooperation with other students, future teachers of other subjects, contributes to improving my teaching competences.					
j In my future teaching practice, I shall strive to plan and realise my teaching through cooperation with teachers of other subjects.					

Received: April 14, 2019

Accepted: August 01, 2019

Dragica D. Trivic (Corresponding author)	Ph.D., Associate Professor and Head of the Chair of Chemical Education, University of Belgrade, Faculty of Chemistry, Studentski trg 12-16, 11000 Belgrade, Serbia. E-mail: dtrivic@chem.bg.ac.rs Website: http://www.chem.bg.ac.rs/osoblje/26.html ORCID: 0000-0001-8511-4354.
Milanka Džinović	Ph.D., Assistant Professor, Faculty of Teacher Education, University of Belgrade, Serbia. E-mail: milanka.dzinovic@uf.bg.ac.rs Website: http://www.uf.bg.ac.rs/wp-content/uploads/uf/06-saradnici/24_Milanka_Dzinovic.pdf
Vesna D. Milanovic	MSc, Teaching Assistant of the Chair of Chemical Education, University of Belgrade, Faculty of Chemistry, Studentski trg 12-16, 11000 Belgrade, Serbia. E-mail: vesnamilanovic@chem.bg.ac.rs Website: http://www.chem.bg.ac.rs/osoblje/461-en.html ORCID: 0000-0002-6765-5031.
Ljiljana Živković	Ph.D., Associate Professor, University of Belgrade, Faculty of Geography, Belgrade, Serbia. E-mail: ljzivkovic@gef.bg.ac.rs , ljiljanazivkovic59@gmail.com Website: http://www.gef.bg.ac.rs/nastavnici-i-saradnici/ljiljana-zivkovic/

