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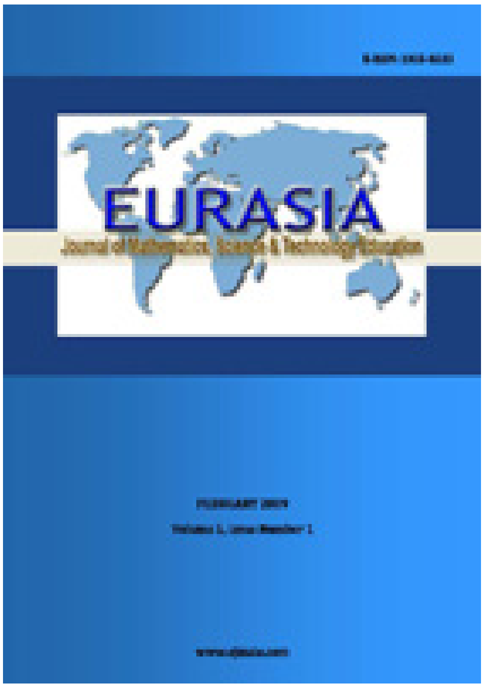

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Syllabi in the science subjects, biology, chemistry and physics at lower and general upper secondary school are compared in the light of their underlying philosophies, goals, objectives and recognized importance in science teaching. Even though all syllabi were prepared within the same framework, great differences among syllabi concerning practical work are evident. More importance is given to practical work in the syllabi of chemistry and physics, where it is recognized as a basic method, while in the biology syllabus the construction of concepts is valued much higher.

Keywords: curriculum, practical work, science, secondary school, syllabus

INTRODUCTION

From findings of numerous scholarly studies summarised in documents from all parts of the world (Abell & Lederman, 2007) we, as science educators, can conclude that science education is at a complex crossroads. Demands for better educated citizens and the need for change in existing teaching and learning practices can be recognized in the following quotations:

Learning and innovation skills are what separate students who are prepared for increasingly complex life and work environments in the 21st century and those who are not. They include: Creativity and Innovation; Critical Thinking and Problem Solving; Communication and Collaboration (Partnership for 21st Century Skills, 2009, p.3).

The knowledge, skills and attitudes of the workforce are a major factor in innovation, productivity and competitiveness and they contribute to the motivation, job-satisfaction of workers and the quality of work (Commission of the European Communities, 2005, p.3).

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In a rapidly-evolving world, science and technology education is an important instrument in the search for sustainable development and poverty reduction. Yet educational systems are faced with the challenge of science and technology education that has lost relevance not being able to adapt to current scientific and technological developments (UNESCO, 2009).

How can people be educated or trained to function appropriately in situations that are unknown at the time of the acquisition? This is actually a question that undermines a great deal of traditional educational thinking which takes as its starting point the formulation of precise objectives and then tries to deduce educational measures from this (Illeris, 2008, p2).

So, if the goal of science education is to participate in the education of citizens – lifelong learners – then instruction should not be informative but formative in nature. The outcome of such instruction should be citizens who are not only competent in knowledge and skills in science, but also competent to make decisions and participate in public debates on science and socio-scientific issues. In science education one route to such an objective is the active student-centred methods of school work (Michael, 2006), such as class discussions, excursions, field work, problem solving, with laboratory work as a flagship (Hofstein & Lunetta, 2004; Hofstein & Mamlok-Naaman, 2007). Inquiry and problem based methods and approaches (Hmelo-Silver, 2004) are

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State of the literature

- Demands for better educated citizens and the need for change in existing teaching and learning practices can be recognized as one of the major political issues in the World.
- In science education one route to educate citizens who are not only competent in knowledge and skills in science, but also competent to make decisions and participate in public debates on science and socio-scientific issues is the active student-centred laboratory methods of school work.
- Through inquiry and problem-based hands-on activities, laboratory and field work make it possible not only to transfer knowledge on higher order cognitive levels and to teach experimental and practical skills, but also to ignite an interest in science among students.

Contribution of this paper to the literature

- This study compare the syllabi of three subjects: Biology, Chemistry and Physics in Slovenian compulsory lower secondary school (grades 8 and 9, 13–14 years, International Standard Classification of Education - ISCED level 2) and general upper secondary school – Gimnazija (grades 10 to 13, 15–18 years, ISCED level 3).
- From the comparative analysis of all three syllabi we can conclude that the authors of the syllabi have different philosophies concerning the role of laboratory work in teaching and learning.
- If teachers are following the paths recommended in all three syllabi, they could potentially produce graduates literate in Biology, Chemistry and Physics but not Science-literate citizens.

superior to direct instruction and expository labs (Domin, 1999). Through inquiry and problem-based hands-on activities, laboratory and field work make it possible not only to transfer knowledge on higher order cognitive levels and to teach experimental and practical skills, but also to ignite an interest in science among students (Šorgo & Špernjak, 2009).

At the moment all science teachers are probably aware that changes are inevitable; this in reality does not mean that their lives are going to become easier. As a consequence, some old and well tested educational practices must be changed, new technologies learned, and many once important topics must be recognized as obsolete. Changes are not accepted or smoothly transferred into everyday teaching by many educators. As an example, we can cite the introduction of the computer supported laboratory into teaching practice (Šorgo, Verčkovnik & Kocijančič, 2010; Špernjak & Šorgo, 2009). The greatest barrier to acceptance of novel ways of teaching is knowledge and experience, especially if they worked well and in line with expectations of parents or administrators, and are in line with their beliefs about teaching (Tondeur, Hermans, van Braak & Valcke, 2008). So all those involved in curricular change should keep in mind that they have to provide teachers with all the necessary support and even more, they must give teachers autonomy and a chance to fail without consequences in their efforts to improve teaching.

One of the most important documents for structuring teachers' methods of teaching in Slovenia is the syllabus for their subject. In Slovenia, syllabi of all subjects in Compulsory and General Education are prepared by committees of experts from universities, The National Institute of Education and invited teachers. Before implementation, they have to be approved by the governmental body, The Council of Experts for General Education, which was established by the Ministry of Education and Sport to make professional decisions in their respective field of competence (Government of the Republic of Slovenia, 2010). The situation is basically identical in vocational and technical education, except that different governmental bodies are involved (Aberšek, 2004). Syllabi are part of the national curricula, mandatory for teachers, who must teach within the prescribed guidelines, which are controlled by school inspection. So, willing or not, in practice teachers mostly follow the main track and spirit of the syllabus provided by the committees. Thus, if the syllabi are overloaded with content and allow only limited autonomy, then it is difficult to believe that teachers would leave the well-paved pathways of direct instruction in favour of laboratory practices that are from their point of view regarded as "time-consuming".

Purpose of the study

The purpose of the study was to analyse and compare syllabi of Biology, Chemistry and Physics to find out if they are enhancers or blockers for the introduction of active, student-centred teaching methods, particularly hands-on laboratory work, in everyday teaching practice at lower and general upper secondary schools in Slovenia.

METHODS

The Slovenian school system

Slovene primary and secondary schools are predominantly public (only a few are private schools - less than 1% of total school population). Because Slovenia is a state with a population of about two

Table 1. Structure of the Slovene school system.

Age in years	Type of school			
12-14	Third cycle (lower secondary education) – 3 years (grades 7-9)*			
9-11	Second cycle (primary education) – 3 years (grades 4-6)			
6-8	First cycle (primary education) – 3 years (grades 1-3)			
15-18	General upper Secondary* (4 years duration; grades 10-14)	Technical upper secondary (4-5 years duration; grades 10-14/15)	Vocational upper secondary (3-4 years duration; grades 10-14)	Short vocational upper second. (2-3 years duration; grades 10-13)
	General Matura Examinations*	Vocational Matura Examinations	Vocational Matura Examinations; VTE Vocational-technical education†	MCMatura Examinations*¥

* Tracked syllabi.
†Two years of technical upper secondary education built on previously completed programme (grades 13-15).
¥General upper secondary second-chance education.

million inhabitants, the number of schools is relatively small (about 450 Grades 1-9 compulsory schools and about 145 upper secondary schools). Compulsory 6-14 years schools and upper secondary schools are almost never in the same building and are independent entities, both by administration, finances, teachers, etc. About 98% of the students continue compulsory education at the upper secondary schools. The basic structure of the system is presented in Table 1.

Science subjects in secondary schools

By regulation, science is taught in primary and lower secondary schools as an integrated discipline between the first and the fifth grade by elementary teachers with the appropriate university degree. In the sixth and the seventh grade it is taught by two-stream teachers, who need additional qualifications to teach the third part of the subject. For example, two-stream Biology – Chemistry teachers need an additional course in Physics. In the eighth and the ninth grade Science is taught as Biology, Chemistry and Physics, by two-stream or single-stream teachers of a subject. In general secondary schools with Matura examinations, by regulation only one-stream, university-educated teachers should teach. Two-stream studies were traditionally offered by the Faculties of Education with a teacher of two subjects as the final goal. One-stream studies were offered by faculties of different natural sciences where students choose between research and pedagogical track in their third and fourth year of study.

In technical and vocational schools, diversity is much greater in both programmes and teaching qualifications. In technical and vocational upper secondary schools, Biology, Chemistry and Physics can be taught as separate subjects or be integrated in subjects like Science, Science and Environment, etc. It is common for only part of the field of a general subject be covered (for example Microbiology, Mechanics, Food Chemistry, etc.). The variety is great, and presenting all possible contents for such subjects is beyond the scope of this article.

We compared the syllabi of three subjects: Biology, Chemistry and Physics in compulsory lower secondary school (grades 8 and 9, 13–14 years, International Standard Classification of Education - ISCED level 2) and general upper secondary school – Gimnazija (grades 10 to 13, 15–18 years, ISCED level 3). In Slovenia, Geography is declared a Social Science Subject, so it is omitted from our study. While in Gimnazija the syllabi in use date from the school year 2008/09, syllabi for lower secondary school have been prepared in the same year. The introduction was stopped by the Ministry of Education and are used in schools beginning with the school year 2011/2012.

Our analysis followed the same method of comparisons of the syllabi of upper secondary general school Gimnazija, where in previous studies we compared the inclusion of cross-curricular themes, and teacher autonomy in the science curriculum (Šorgo & Šteblaj, 2007). We chose to analyse only the compulsory part of the syllabi of science subjects in the general Gimnazija programme, and omitted an elective additional year of science subjects or elective courses as part of the compulsory Matura examination as a prerequisite to enter post-secondary university studies. The reason was that, for the major part of the student population on entrance to university, compulsory science education ended in the third year of the Gimnazija programme. Such acquired science knowledge and skills can be recognised as a publicly negotiated standard for the quantity and quality of science concepts and competences needed for understanding the material world and making informed decisions for students who will not enter science/technology studies, such as graduates in Humanities, Law, or Social Sciences. Besides the general Gimnazija programme, there exist several other

Gimnazija programmes (classical, economic, technical, sport, etc.). In most cases such programmes are taught in a class or two alongside general programmes at the same schools. They can have fewer hours dedicated to some of the science subjects, but by the end of schooling every student can fulfil the prescribed requirements with elective courses and end his/her schooling with the Matura examination in elective science subjects.

Comparisons were easier because all three subjects are taught inside a framework of basically equal numbers of hours (Tables 2 and 3) and the syllabi follow the same structure of seven chapters: Description of the Subject, General Goals and Competences, Content and Objectives, Intended Outcomes, Cross Curricular Connections, Didactic Recommendations, and Assessment. In the present study we have evaluated in detail the chapters General Goals and Competences, Content and Objectives, and Didactic Recommendations because of their central role in laboratory activities.

Analysis of the syllabi

Syllabi are prepared as booklets, and for example, the Biology syllabus at the upper secondary level has 71 pages. The syllabi of all three subjects (Biology, Chemistry, and Physics) follow the same general scheme and order of chapters. In reality there are six different syllabi - two for each discipline, to cover lower secondary and upper secondary level.

Chapter: Description of the Subject

Because syllabi for each subject were prepared by the same committee, differences in description of the subject between the lower and upper level of each subject are small. On the other hand differences among subjects are much greater. Differences among subjects are clearly recognizable even at the descriptive level and in the underlying philosophy of teaching strategies and methods of classroom work presented in the introductory section. In Biology the main goal is to develop understanding of a science worldview and acceptance of informed personal and pro-society decisions (active citizenship). Biology is presented as a contemporary, complex, and hierarchical science with the goal of investigating living systems. At the lower secondary level, students should learn that observation, experimental work and holistic interpretation of data are some of the methods of recognition in a complex system like biological knowledge. They should be warned that such methods have their limits. Practical or experimental laboratory work is not mentioned in this section at the Gimnazija level.

On the other hand, Chemistry is recognized as basic experimental science where experimentation remains as a basic method of school work through which students should acquire chemical and science literacy and positive attitudes toward chemistry and science.

At the descriptive level, Physics is somewhere between Biology and Chemistry. There is a difference on the descriptive level between lower and upper secondary school. In lower secondary school students should acquire new knowledge and gain insight into the interconnectedness of science phenomena through active experimental work, and thereby develop positive attitudes and values towards the environment. In upper secondary school, a stronger emphasis is placed on the ability to inquire into natural physical phenomena in such a way as to acquire the language and methods used

Table 2. Science subjects and weekly hours dedicated to the subjects in compulsory 9-year education

Subject	Grade									Sum
	1	2	3	4	5	6	7	8	9	
Environmental Studies	3	3	3							315
Science and Technology				3	3					210
Science						2	3			175
Biology								1.5	2	116,5
Chemistry								2	2	134
Physics								2	2	134
Technic and Technology						2	1	1		140
Elective subjects							2 -3	2 - 3	2 - 3	240/306
Science days (days/year)	3	3	3	3	3	3	3	3	3	/

Table 3. Science subjects in general secondary education.

Subject	Grade				Sum
	1	2	3	4	
Biology	2	2	2	4[1]	210 (350)
Chemistry	2	2	2	4[1]	210 (350)
Physics	2	2	2	4[1]	210 (350)

[1]*Elective for students who choose one or two elective science subjects as part of the general Matura examination*

in physical research. Students should be informed about basic concepts and theories underlying knowledge about the material world, and machines and devices met in everyday life. Practical or experimental laboratory work is not mentioned.

Chapter: General Goals and Competences

In both Biology syllabi competences are not mentioned even if they were in the title of the chapter (they are later included in the chapter concerning didactic recommendations). The most important goal is defined as the development of a holistic understanding of biological concepts and the connections among them in a network of knowledge. Connections between concepts are presented in the form of diagrams. In the lower secondary syllabus, 16 goals/competences are listed. Two of them can be recognized as connected with practical work. Students should develop a) learning based on observation and experiments and practical skills (for example, handling biological materials); b) ability to responsibly cooperate in tasks, including the planning and performing of simple biological research (experiments and observations), and the ability to interpret results and perform complex thinking. In the Gimnazija programme, in the list of seven general goals we cannot recognize any goals connected with intended skill in or knowledge of laboratory practice.

In Chemistry and Physics it is clearly stated that both subjects should develop experimental skills and eight key competences as a combination of knowledge, skills and attitudes appropriate to the context are listed (Commission of the European Communities, 2005).

The importance of Chemistry on both levels is especially recognized in developing mathematical competence and basic competences in science and technology for developing complex and critical thinking by "searching, manipulating and evaluating data from different sources by planned observations, note taking and use of observations/measurements as a source of data; ... use of ICT for collecting, saving searching and presentation of data", and "development of experimental skills and methods of inquiry". Students should develop experimental skills and methods of inquiry by "training in choosing and using of appropriate and safe equipment; identifying experimental factors; the distinction between constants and variables; assessment of the reliability of the obtained results; reference to an informed conclusion of the presentation".

It was recognized that Physics can develop practical and laboratory skills in digital competence: "Students acquire this competence with work on devices based on digital technology, computer programmes and internet. In experimental work they acquire knowledge and skills by use of computer as a data-logging device". Taking responsibility for a healthy life as part of social and civic competences is recognized as one aspect of experimental work: "by experimental work students acquire knowledge and skills in safe experimenting, use of protective devices and safe use of modern technical devices". In the lower level syllabus it is clearly stated that students should systematically develop insight in to the importance of experimentation in the recognition and evaluation of physical laws.

Chapter: Content and Objectives

The Chapter on Contents and Objectives is the central and most important chapter from the teachers' points of view. Because every teacher is obligated to prepare lesson plans, objectives are often transferred into such plans on a copy and paste basis. Some teachers blindly follow the content order and proposed amount of time for a topic. In many cases if something (content or method) is not mentioned in this part of the syllabus, it is commonly not transferred into teaching practice either.

Lower secondary school biology. The content of this chapter is organized in sections where following the title of the section; the leading concept is presented, followed by a number of goals and objectives. All the information about laboratory and practical work is contained in the section "Inquiry and Experiments" as the second section of the chapter Content and Objectives. The section comprises ten goals, which are additionally divided into two parts (one part for eighth and one for ninth grade). In both parts it is stated that "Process goals from this section are achieved by insertion in the other content sections and must be realized in at least 20% of all academic hours where students should work in groups".

From the list of ten goals and objectives, it can be recognized that the writers of this section have in mind all classroom instructional activities, not only hands-on or practical activities. For example, these are the stated goals: "students should know how to find and use different paper and digital sources for collecting information for their research project and to critically evaluate their validity", and "students can differ between linear and nonlinear relations presented in graphs". Specific laboratory methods, field-work or suggested titles for exercises are not mentioned in this chapter.

Because teachers are recognized as autonomous in choosing methods and strategies in their work with students, the suggested practical activities are later listed only sporadically without a definite order. Thus, among methods, only microscopy (of chromosomes, observation of cells, blood cells, etc.) is repeatedly mentioned, once for observation of a reflex arc and once for antagonistic muscle action on their own bodies. Even in chapters like Chemistry of Living

Beings, Classifying of Organisms, or Biotic Diversity, where hands-on activities are "traditional", they are not mentioned.

Upper secondary school biology. The chapter started with a sentence that at least 20% of the instruction (42 hours of 210) should be in the form of laboratory and field-work. As in the lower secondary school syllabus, all goals and objectives are put together in one section entitled Inquiry and Experiments. At the beginning of this section it is recommended that students should work in groups in the presence of the teacher and teaching assistant. The teacher is given autonomy in including the listed goals in other sections. From the list of 12 goals, it cannot be recognized which practical techniques or procedures should be experienced by students because the goals are written in a general form. Examples of such goals are as follows:

> ***Goal 1:*** *Students should understand approaches to research work in biology (microscopy, biochemical investigation, physiological research, and field work, use of information and communication technologies (ICT) in measurements and presentations of research results.*
>
> ***Goal 3:*** *Based on simple examples they should know how to plan and use methods of observation and experimenting and collect qualitative and quantitative data.*
>
> ***Goal 9:*** *use critical thinking skills in everyday lives (conclusions on the basis of arguments, for example evaluation of claims in media).*
>
> ***Goal 11:*** *can make a distinction between scientific and non-scientific explanations.*

Such goals should be written in the Chapter General Goals and Competences, for this chapter is worded in too general a manner to be of great help to teachers when transforming them into teaching practice. Among several tens of goals, which mostly start with the verbs "to understand" and "to learn", we have succeeded in finding only one which is operational: "students should use the microscope, sketch cells and mark their structures". At the end of the chapter there is a section entitled Process Goals. Among these 10 goals, only one contains the word "experiment": "Students should develop competence in planning and performing of simple biological experiments and inquiries, and interpretation of results."

Lower secondary school chemistry. The introductory paragraphs of this chapter indicate that the goals and objectives are organized in sections. The teaching order and when to work on a specific goal is left to the teacher's decision. Laboratory or practical work is not mentioned, and teachers are instructed to give priority to methods corresponding with the objectives. In each subsequent chapter the following statement appears: "Students develop the ability to observe and to implement an experimental approach." Only in two sections is this statement broadened. In the section "Chemistry is the study of matter" it says: "Students develop the ability to observe and compare different properties of elements and compounds in the school collection and to develop an experimental approach", and in the section Chemical Reactions: "Students develop an experimental approach and laboratory skills by inquiry into chemical reactions and deepen knowledge of chemical safety and safe work with chemicals." Typical experiments or experimental procedures are not mentioned in this chapter.

Upper secondary school chemistry. The number of hours dedicated to experimental work is not mentioned as is the case with Physics or Biology, but only appears later in Didactic Recommendations. In the syllabus, the first section is entitled "Introduction to Safe Experimental Work". The goals in this section are more practical and operational but not very precise. Among other goals, students should recognize basic laboratory equipment, should be trained in basic laboratory techniques and should develop laboratory approach (basic skills and techniques). Three goals are dedicated to safety. There is a list of suggested topics, which are very general in one section and not very operational (Chemistry is an experimental science; examples of different experiments; basic laboratory techniques, Basic laboratory equipment), and in the other part very precise (use of digital scale, handling the Bunsen burner).

Every subsequent section of this chapter includes a variation of a statement concerning experimental work. This starts with the words, "Students should ... develop the ability to observe and an experimental approach to....". Selected examples are as follows: .".. to physical and chemical properties of elements from the first and seventh group of elements in the periodic system and their compounds; ...in preparation of solutions; ... in protolithic reactions, etc." On several occasions goals concerning chemical safety are included.

Lower secondary school physics. In contrast to the syllabi for Biology and Chemistry, the Physics syllabus offers suggestions for practical work in each section, and titles and short descriptions of typical experiments are named. The recommendations state, "Students should learn methods and forms of work through practical examples. Methods and forms are presented as simple experiments and students should find by themselves the causes and outcomes of experiments and in such a way understand simple physical laws." Wherever the writers of the syllabus recognize a suitable point for an experiment to be performed, they specify the name and a short description of the experiment. In such a manner, the teachers' autonomy is not minimized because teachers are allowed to change or upgrade experiments. Only two examples among many are presented:

> *Relation between the focus of a convex lens and creation of an image are investigated experimentally.*

In an electrical circuit, measure current and voltage on a resistor. Draw a graph, and write Ohm's law.

We can recognize that these examples from the Physics syllabus do not restrict the teacher's autonomy but do enforce the use of practical work in instruction.

Upper secondary school physics. In the upper secondary school syllabus, a completely different approach is used. Knowledge is divided in to three groups: general, special and elective. The number of academic hours dedicated to each group is suggested as 30 hours (from 70 in each of the first three grades; see Table 3) goes to general knowledge, 15 to elective content, 10 to experimental work and 15 to assessment and grading. Only after the titles of the sections is the number of hours dedicated to experimental work suggested. For example, in the chapter Measurements, Quantities, Units, 3 hours out of 8 should be experimental. In the chapter Newton's Laws and Gravity, 2 hours out of 7 should be experimental. All goals listed are knowledge based and no experimental work or named experiment is mentioned.

Chapter: Didactic recommendations

Didactic recommendations constitute a chapter where the authors of the syllabi recommend to teachers methods and strategies by which the content presented should be taught. Careful reading reveals the key sentences in understanding others´ views of what works in the classroom. In the Biology syllabi, we find the idea that the teaching of Biology must be based on a scientific foundation i.e., on refutable theories and hypotheses. Teaching should not be dogmatic and should enhance understanding and critical thinking based on the content and concepts listed in the syllabus. The work of scientists should be presented as something that underpins the facts and concepts presented in the textbooks. The most important goal of teaching is holistic understanding of Biology - an understanding of concepts and of the connections among them. Students should deepen their understanding of concepts by experimental and field-work and other activities as often as possible. Evolution is recognized as a most important concept that clearly separates Biology from the other disciplines, and practical work should follow the steps of scientific inquiry. Even if whole paragraphs are dedicated to laboratory and experimental work, the importance of including contemporary issues and themes relevant to society in the spirit of the syllabus can be unmistakably identified in the statement: "For good understanding of some biological concepts and goals, it is best that students hear about them additionally as direct instruction; other knowledge can be achieved (underlined by the authors of the paper) through individual inquiry and other activities." This concept is strengthened in the upper secondary Biology syllabus: "Biological – Science – education trains the intellectual power of a mind. As such, Biology teaching must be at levels of understanding much higher than the knowledge of an average citizen...."

In contrast to Biology, the Chemistry syllabi state that, "Contemporary Chemistry teaching should focus on experimental problem-based and inquiry-based approaches. In the understanding of Chemistry content, processes and methods of achieving knowledge are important." Content should be presented in problem form, but problems should be linked to [students'] interests." Teachers are regarded as autonomous in the selection of appropriate experiments, and students should be involved in the "process of selection, planning and preparation of experiments". Experimental work should be expanded whenever possible with field work, or the use of ICT (data-loggers, cameras, etc.). Practical work can be extended by use of video materials, but should be replaced only as an exception, if experiments are too dangerous, costly, or too long. Experimental work should be based on the work of students as individuals, in pairs, or group in work. At forty percent of the instruction in the form of individual experimental work and demonstrations, a teaching assistant should be present, and each student should perform at least 30 hours of compulsory programme in the chemical laboratory.

The creators of the Physics syllabus fall somewhere between the opinions of the creators of the Biology and Chemistry syllabi. They are well aware that the teaching of Physics regularly proceeds mostly as direct instruction and warns teachers that, "Traditional exercises should be replaced with modern approaches, where the goals are to developing independent inquiry, thinking, reasoning and simple research, to achieve new content by experimenting,..., inclusion of contemporary measuring instruments, etc. ... it is desirable that students perform experiments at different complexity levels." Experiments are regarded as "central agenda in physics teaching", and the "Important part is computer supported measurement with data-loggers and sensors."

DISCUSSION AND CONCLUSIONS

From the comparative analysis of all three syllabi we can conclude that the authors of the syllabi have different philosophies concerning the role of laboratory work in teaching and learning. From the recommendations (Ivanuš-Grmek, Javornik Krečič & Vršnik Perše, 2007) that preceded preparation of the curricula and syllabi for these subjects, it can be deduced that the authors read these recommendations in different ways.

The most promising in terms of its contemporary constructivist and inquiry-based, student-centred teaching and learning approach is the Chemistry syllabus, followed by the Physics syllabus. The difference between subjects is probably the outcome not only of differences in underlying philosophy, but also of the nature of experiments. As such, short demonstration experiments can be recognized as a key component of Physics teaching, followed by discussion. In both syllabi, the use of ICT equipped with data loggers is encouraged. The basis for such reasoning is that in the last decade all upper secondary schools received computers equipped with data loggers to be used in science teaching. So it comes as a surprise to find that in the Biology syllabus their use is not encouraged, even though they have been successfully used in Slovenian schools (Šorgo & Kocijančič, 2006; Šorgo, Hajdinjak & Briški, 2008), and we know that the writers of the syllabus are aware of its existence in schools.

On the other hand, a reading of the Biology syllabus reveals that it was not written from a recognition of the student as active participant in constructing knowledge; instead, this syllabus is teacher-centred. Teachers are given full autonomy to organize their teaching and use various teaching methods and strategies, among them practical work with students. However, from the list of goals and didactic recommendations, we can deduce that practical activities are predominantly regarded as functioning to clarify concepts and illustrate the science content of the subjects and not as intended learning outcomes. Students are not given a role in constructing their teaching experiences according to their interests. This is contrary to the aim that laboratory and field work should be the dominant forms of school work (Šorgo & Špernjak, 2009).

Even if these syllabi were written under the same curricular umbrella, it is clear that there must have been a lack of communication between writers of the different parts of the Science curriculum. Cross curricular themes and interdisciplinary connections are missing, which is a familiar problem with all Slovenian curricula (Šorgo & Šteblaj, 2007). As a result of such subject-set syllabi is lack of cross-curricular and interdisciplinary themes in textbooks and learning materials and final examinations do not require cross-curricular integration.

Subject syllabi reflect opinions about what good teaching is, and the relative importance given to some topics as opposed to others of the most influential personalities on committees; a pattern found in the Geography syllabus, as well (Kolenc Kolnik & Konečnik Kotnik, 2009).

In conclusion, we can claim that if teachers are following the paths recommended in all three syllabi, they could potentially produce graduates literate in Biology, Chemistry and Physics but not Science-literate citizens in a light of movements and initiatives such as Science for all, STS (Science Technology Society), PUS (Public Understanding of Science or SSI (Socio scientific issues) (Bauer, Allum & Miller, 2007; Marks, Bertram & Eilks, 2008; Holbrook & Rannikmae, 2007; Osborne, 2007; Sadler & Zeidler, 2009).

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