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SCIENTIFIC KNOWLEDGE OF TEACHER STUDY STUDENTS

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ABSTRACT

This study was conducted with the aim of questioning Integrated undergraduate and graduate university Teacher Study students (N = 132) about their scientific literacy. For this purpose, a questionnaire was prepared with questions from the Science and Social Study textbooks. Questions were grouped according to Bloom's Taxonomy cognitive domain: Group 1 (Level 1 and Level 2 outcomes: list, name, identify), Group 2 (Level 3 and Level 4 outcomes: classify, relate, separate), and Group 3. (Level 5 and Level 6 outcomes: choose, evaluate and select). The research results show a low level of scientific literacy (51% correct answers). Students showed a good level of knowledge in the first group of questions (69%), and inadequate level of knowledge in the third (48%) and second group (38%) of questions. The main problems observed were sorting plants and animals that live in rivers, lakes, and the sea. Students showed an inadequate knowledge of herald of spring. The results of this study can help in students' self-evaluation of knowledge. In order to achieve an appropriate level of scientific literacy for university students, recommendations were made for their development within the curriculum of Integrated undergraduate and graduate university Teacher Study.

Keywords: teacher education, learning outcomes, Science and Social Study lessons, scientific knowledge, science.

1. INTRODUCTION

Natural science contents are deeply rooted in the human spirit, and since the time of the early man human curiosity about understanding life and the living world to which humans belong to has been innate. This continues up to the present contemporary society characterised by a fast development of technology, and consequently to numerous possibilities of finding new scientific knowledge (Kostović-Vranješ, 2015). Learning about natural science is necessary for the development of the value system of each individual to live and work in the 21st century. Therefore, one of the important tasks of education is the sole learning of natural science contents and the acquisition of knowledge about natural phenomena and systems, as well as the attainment of natural science literacy and competencies (MZOS, 2011). Since the youngest age, children are narrowly connected to their environment. They constantly observe, inspect, study, describe, discover and measure it. Therefore, the overall initial natural science teaching should be based on the interaction of pupils and their environment, which is enabled by the choice and schedule of natural science teaching materials (De Zan, 2005). Natural science is based on the cognition reached by natural sciences: physics, chemistry, biology, geography and geology. In Croatia, pupils at the beginning of their education are introduced to natural science contents in the subject Science and Social Studies.

The subject Science and Social Studies has an important place when it comes to primary school teaching contents because without the knowledge of nature and natural phenomena it is impossible to imagine life and work. Science and Social Studies is a very complex subject, encompassing a wide range of contents, from the wild life and inanimate nature, geographical and historical contents, economic contents, sociological contents, cultural contents, health education, traffic education, up to ecology education and other contents. The mentioned educational contents of the subject Science and Social Studies should be flexibly correlated and organised, and they should be interdisciplinary and linked to real life. Teachers should include pupils in interdisciplinary learning because such learning methods avoid irrationality, fragmentation and isolation of teaching materials, and enable the perception of contents from different points of view, as well as the establishment and research of correlations among different subjects' contents (Kostović-Vranješ, Šolić, 2011). Except interdisciplinary learning, it is important to awaken various levels of knowledge with pupils, and in this sense the textbook and workbook should have the basic role since they should offer contents and questions at two to three levels of knowledge (Borić, Škugor, 2011). During Science and Social Studies teaching, it is necessary for teachers to have competencies relating to their methodology

knowledge and teaching skills, but also competencies including the basic and general knowledge of a few substrate sciences forming the fundaments of the subject Science and Social Studies (Letina, 2012). The research conducted by Appleton and Kindt (2010) shows that teachers lack confidence in teaching Science and Social Studies due to their personal lack of knowledge and the difficulty of teaching materials.

Understanding natural science concepts is the main goal in establishing a society's literacy about natural science (MZOS, 2011). The advancement of future teachers' natural science literacy is extremely important (Azevedo and Duarte, 2018), because their natural science literacy has a direct impact on the formation of natural science literacy of pupils in primary education (Letina, 2019). Students enrolled at teacher studies in the Republic of Croatia build upon and supplement their natural science literacy during subject courses Natural Science, Ecology, Research based teaching of Science and Social Studies, and in the end Methodology of Science and Social Studies Teaching. These subject courses should be systematically connected and supplement each other in study programmes, and also follow one another during study years. Students should be educated so as to directly and clearly include natural science contents into other subjects and courses because such contents enable students to understand nature and life surrounding us into more depth (Verdugo Perona et al., 2016). Future teachers' educational curricula should include learning outdoors, which was confirmed by Anđić (2007) in her examination of students who expressed that learning and teaching taking place outdoors was considered an extremely significant dimension of the educational work in primary teaching. Furthermore, curricula intended for teachers should be directed toward the active conduction of research oriented teaching, because it is advisable and necessary to improve the natural science literacy of primary education pupils (Letina, 2016).

In their paper, Ćurić et al. (2014) compared the university study syllabi of the subject course Nature and Technics at the VIA University College in Denmark and the Methodology of Science and Social Studies teaching at the Universities of Rijeka and Pula, and they found there was a difference in the number of teaching hours and objectives. The number of teaching hours of the subject course Nature and Technics is much higher than of Methodology of Science and Social Studies Teaching, and students are more trained for the scientific and innovative work, whereas the subject course Methodology of Science and Social Studies Teaching prepares them more for didactic and methodology competencies attainment. Ćurić et al. (2014) claim that today's study programmes train teachers in the area of general competencies, and after completing their studies they are competent to plan and conduct methodically correct teaching, follow up pupils, assess their

knowledge, evaluate the teaching process, keep records, etc., which is extremely important and forms the basis for the teaching profession. However, it must not be forgotten that science and social studies encompass a very wide area which is not only socially oriented, but belongs to the area of natural sciences which are still unfairly neglected in the Croatian educational system. This is also supported by the results in the international assessment of knowledge and skills (PISA, 2012) according to which, unfortunately, our students showed to be significantly below the average in comparison to pupils from other countries when it comes to mathematics, natural science and reading literacy. Therefore, it is necessary to train teachers for natural scientific and innovative work, as well as for life-long learning in order to stimulate these competencies among pupils.

Teacher study students coming from four regional centres of the Republic of Croatia evaluate themselves as very self-efficient in teaching science and social studies (Škugor, 2015). The same respondents claim to understand science and social studies contents sufficiently enough to be efficient in teaching them (they gave themselves the average grade of 3.85), and that they will usually be able to answer pupils' questions linked to science and social studies teaching materials (they gave themselves the average grade of 4.00). However, the extent to which students really understand contents, or the natural science concepts in the Science and Social Studies subject, has not been examined.

2. RESEARCH METHODOLOGY

2.1. Research Objective

The aim of the research was to examine the future teachers' knowledge of natural science concepts. They were students of the Integrated undergraduate and graduate university teacher study of the Juraj Dobrila University of Pula. It wanted to find out about the level of understanding teaching contents and concepts found in the Science and Social Studies textbook used in primary teaching, and compare the knowledge of students attending different study years regarding the questions at different levels of the cognitive domain according to Bloom's taxonomy.

2.2. Research problems

Based on the set objective, the following research problems have been detected:

a. What is the level of knowledge about natural science concepts which students of the teacher study have?

b. What is the level of knowledge about natural science concepts regarding the cognitive domain learning outcomes?
c. Is there a difference in the knowledge of natural science concepts regarding the study year of the teacher study students?
d. Which teaching contents do students understand the least and will not be able to teach them to their pupils in their future work?

2.3. Research hypotheses

The set research problems led to the following hypotheses:

(H1) The teacher study students' knowledge of natural science concepts is above 70%.

(H2) Students at the final study year show a better understanding of natural science concepts than first-year students.

(H3) Students attending different teacher study years equally solve tasks at different levels of the cognitive domain outcome.

(H4) Students have the best knowledge of natural science concepts linked to nature and men, while they poorly recognise plant and animal species and can partly sort them out according to the habitat they belong to.

2.4. Research instruments

To determine the natural science knowledge owned by students enrolled at teacher study programmes a questionnaire has been formed which is based on the analysis of the textbook and workbook published by Školska knjiga and used for Science and Social Studies teaching (De Zan et al., 2013a; De Zan et al. 2013b; De Zan et al. 2013c; De Zan et al. 2013d; De Zan et al. 2013e; De Zan et al. 2013f; De Zan et al. 2013g; De Zan et al. 2013h). The questions were analysed with regard to Bloom's taxonomy outcomes (Bloom, 1956) and categorised into three groups so as to present the results more easily. Questions relating to alternative ways of assessment were chosen in order to avoid mistakes during assessment and comparison of levels of knowledge. The first group of questions included the first and second level of outcomes from the cognitive domain (knowledge, understanding), the second group of questions consisted of the third and fourth level of outcomes (application, analysis), whereas the third group of questions included the fifth and sixth level of cognitive outcomes (synthesis, assessment). The first part of the questionnaire consisted of socio-demographic variables (sex, age, study year). The second part of the questionnaire comprised tasks which students had to solve in 45 minutes. The first group of questions included statements which should have been marked

by students as true/false and of gap filling tasks (outcomes: cite, mark, name). The second group of questions comprised tasks demanding for the categorisation of concepts, correlation of concepts and odd-one-out tasks (outcomes: classify, sort, choose). The third group of tasks related to multiple choice tasks (outcomes: correlate, estimate and choose).

2.5. Respondents and conduction of the research

The research was conducted by the students' willing participation, anonymously, in written form. All the students (N=132) handed in their tasks on time. The first part of the research was conducted at the end of the 2017/2018 academic year when 88 students from the first to the fifth study year were analysed. In 2018/2019 and 2019/2020 as many as 34 students of the first study year were questioned. There were 97% of female students and 3% of male students participating in the research, of which 37% were at their first, 20% at the second, 16% at the third and 16% at the fourth, and 11% at the fifth study year.

The statistical differences in the number of correct answers given by first to fifth year students of the teacher study, and the differences in the number of correct tasks in each group were calculated by the non-parametric test Kruskal-Wallis, with the significant difference of 0.05. All tests were conducted in the program Statistica 9.0.

2.6. Results and discussion

The examination of the natural science knowledge through a questionnaire is conducted at all levels of education, from primary education pupils to students and teachers (Neev et al., 2008; Graziani et al., 2013; Minshew et al., 2017; Letina, 2019).

2.6.1. Students' natural science knowledge

Considering the overall natural science knowledge of the teacher study students it can be concluded that it is unsatisfactory, and that students answered with 51% of correct answers to questionnaire questions.

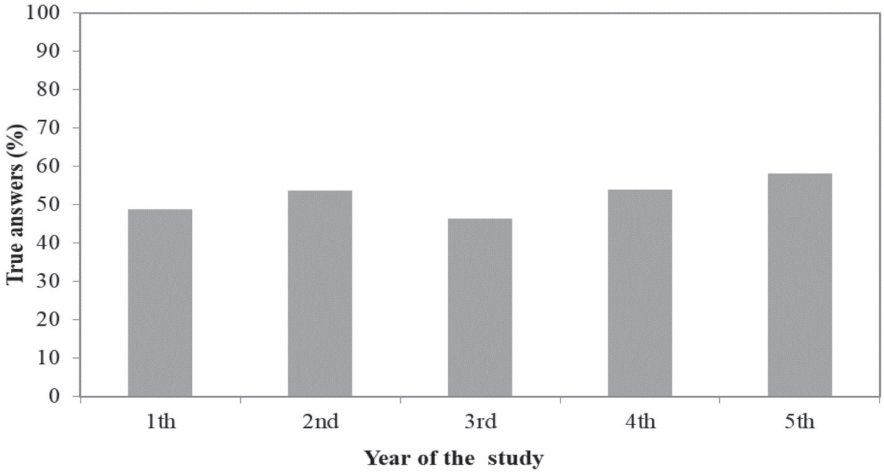

Chart 1. Natural science knowledge by teacher study students regarding their study year

Chart 1 presents the results of natural science concepts knowledge by teacher study students regarding their study year. Considering the overall results of natural science concepts knowledge by students from the first to the fifth year of the teacher study programme, a significant difference can be noticed (Kruskal-Wallis test, H=27.07, p=0.0001). Chart 1 shows that first-year students answered with 49% of correct answers, which is different from second-year students (Mann Whitney, p=0.044). The second-year students answered with 54% of correct answers, which is different from third-year students (Mann Whitney, p=0.002), fourth-year students (Mann Whitney, p=0.002) and fifth-year students (Mann Whitney, p=0.004). Third-year students answered with 46% of correct answers, fourth-year students had 54% of correct answers, whereas those attending the fifth year had 58% of correct answers. It can be concluded that fifth-year students have the vastest knowledge of natural science concepts when compared to other years, whereas first-year students (49%) and third-year students (46%) know natural science concepts to the lowest extent. Since fifth-year students, who are at the end of their teacher study programme and have passed the exams Natural Science, Fundamentals of Ecology and Methodology of Science and Social Studies Teaching, have the best knowledge of natural science concepts, it can be assumed that knowledge is gradually built, although not at the expected pace.

Based on the obtained results, the hypothesis (H1) assuming that students have a satisfactory (more than 70%) knowledge of natural science concepts is rejected.

2.6.2. Natural science knowledge: difference among first to fifth-year teacher study students

Future teachers are expected to have a higher level of natural science literacy, which implies a good knowledge of materials and topics taught in the subject Science and Social Studies. Considering the overall results of natural science concepts knowledge according to the level of knowledge owned by first to fifth-year teacher study students, a significant difference can be noticed (Kruskal-Wallis test, H=8.76, p=0.012). Students were best at solving the first and second level of knowledge tasks, followed by the fifth and sixth level, and then by the third and fourth level of knowledge of the Bloom's taxonomy cognitive domain. The difference between the first and second level of knowledge is statistically significant (Mann Whitney, p=0.009).

Chart 2 presents the results of natural science concepts knowledge by students of the teacher study programme according to the levels of knowledge classified into three groups.

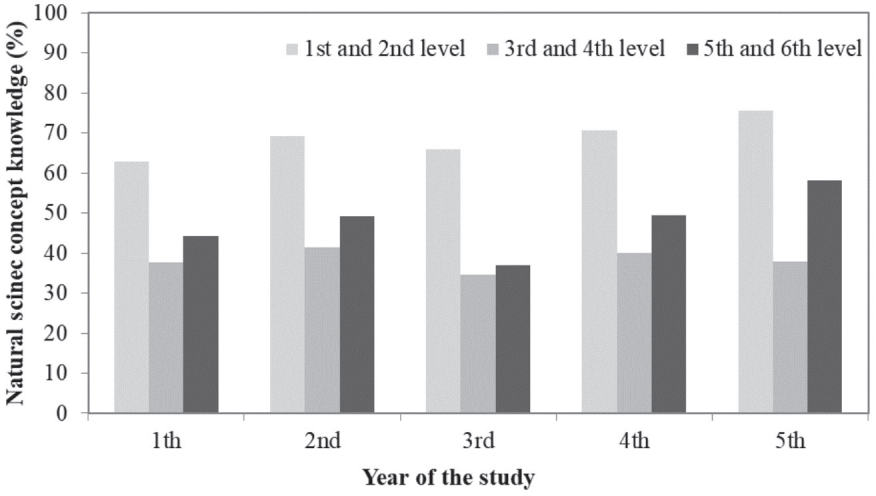

Chart 2. Presentation of results of natural science concepts knowledge classified into three groups

Knowledge of natural science concepts according to the first and second level of knowledge of the cognitive domain is different for first to fifth-year teacher study students (Kruskal-Wallis test, H=16.27, p=0.002). First-year students answered the first-group questions with the lowest percentage of correct answers (63% of correct answers), while fifth-year students showed the best knowledge in comparison to other study years (76% of correct answers).

Knowledge of natural science concepts according to the third and fourth level of knowledge of the cognitive domain is not different among first to fifth-year teacher study students (Kruskal-Wallis test, H=4.279, p=0.368). All five years students answered with 40% of correct or less correct answers at questions belonging to the third and fourth level of knowledge. Knowledge of natural science concepts according to the fifth and sixth level of knowledge of the cognitive domain is different for first to fifth-year teacher study students (Kruskal-Wallis test, H=10.85 p=0.028). The lowest percentage was achieved by third-year students with 37% of correct answers, then first-year students (44% of correct answers), second-year students (49% of correct answers), then fourth-year students (50% of correct answers), whereas fifth-year students achieved 58% of correct answers.

Based on the obtained data it can be concluded that the students' natural science knowledge according to different levels of knowledge is not satisfactory. Poorly coping with questions from the third and fourth level of knowledge and the unusually better fifth and sixth level of knowledge is especially emphasized. Namely, future teachers are expected to have an equal level of natural science knowledge with respect to learning outcomes of the cognitive domain.

Due to the obtained results the hypothesis (H2) assuming that students attending the final teacher study year have a higher level of natural science literacy is accepted. Furthermore, the hypothesis (H3) assuming that students can equally solve tasks at all levels of outcomes of the cognitive learning domain is rejected. Textbooks and workbooks which were used in Science and Social Studies teaching before the introduction of the subject curriculum had questions at a lower level of knowledge (Borić and Škugor, 2011). When these results are compared to this paper results it can be concluded that the fact that students are best at solving first and second level knowledge tasks is not surprising since these are the levels which were mostly present in textbooks and workbooks.

2.6.3. Understanding scientific contents: difference in natural science concepts

Chart 3 results present the natural science scientific contents in tasks set according to outcomes of the first and second cognitive domain.

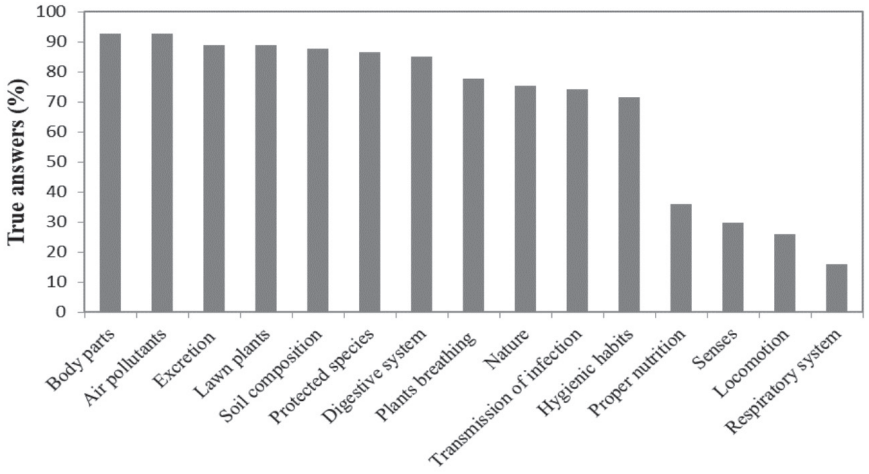

Chart 3. Representation of scientific contents understanding according to outcomes of the first and second cognitive domain

Results shown in Chart 3 show that students are most familiar with human body parts (93% of correct answers), air polluters (93% of correct answers), excretion of substances from the organism (89% of correct answers) and lawn plants (89% of correct answers). They have a very good knowledge of the soil composition (88% of correct answers). Students are successful at naming one plant and one animal species (86% of correct answers) and at marking the parts of the digestive system (85% of correct answers). Furthermore, they are very good at naming the gas exhaled by plants (78% of correct answers). They know well the concept of nature (75% of correct answers) and name ways of infection transmission (74% of correct answers) as well as hygiene habits (72% of correct answers). Students are extremely bad at naming the senses through which people feel their environment (30% of correct answers), and have the least answers about movement organs (26% of correct answers) and the human respiratory system (16% of correct answers). It is important to mention here that when answers were incomplete or partially incorrect, it was not counted as a correct answer. It should also be considered that students were exclusively questioned about the knowledge of primary education contents, and the notation of correct answers was agreed upon in advance.

Chart 4 data show a lack of understanding and insufficient students' natural science knowledge linked to most of the natural science concepts where they had to sort out, link concepts or classify them according to a common characteristic. These results point to the need to encourage students to solve tasks and problems which come as the results of higher levels of knowledge.

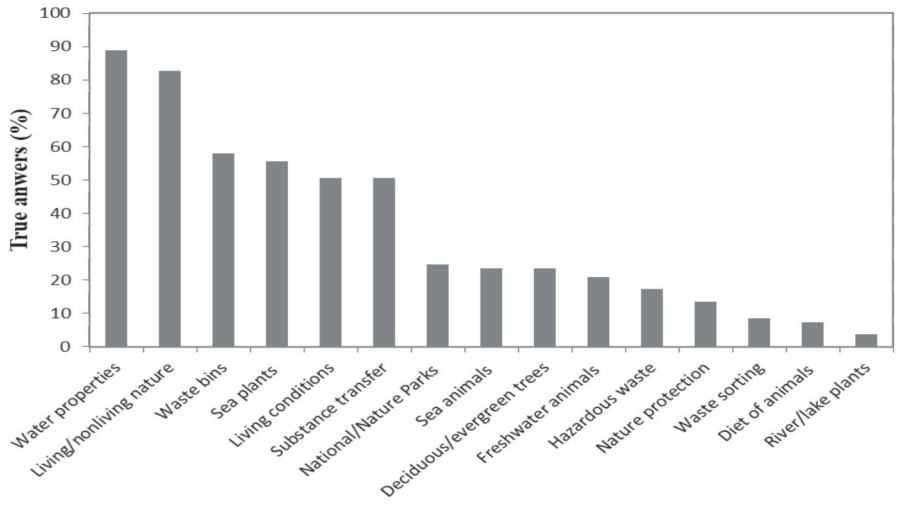

Chart 4. Understanding scientific contents according to the third and fourth level of knowledge

Most students correctly classified the features of water (89% of correct answers) and wild life and inanimate nature (83% of correct answers). Here the second-year students can be pointed out since they determined what wildlife and what inanimate nature is completely correctly. As many as 58% of students are not able to determine the colour of containers according to the type of waste disposed of in them. Half of the students (51% of correct answers) did not recognise the basic life conditions and determine the transmission of substances through blood. There were problems in classifying National Parks and Natural Parks (25% of correct answers). Most students did not even try to answer about the difference between a National Park and a Natural Park. Regarding the classification of National Parks and Natural Parks, most students classified North Velebit and Mljet as Natural Parks, and Velebit as a National Park. It can be noticed that students know the difference between deciduous and evergreen trees, but do not know if certain types of trees belong to the one or the other (23% of correct answers), and they classified birch and hornbeam as evergreen trees. The classification of animals which live next to and in the sea was extremely difficult for students (23% of correct answers), as was the classification of animals living in flowing or stagnant waters (21% of correct answers). The lowest level of knowledge was shown at disposing rubbish into appropriate containers (9% of correct answers), classifying animals as herbivores, carnivores and omnivores (7% of correct answers), and classifying plants which live next to stagnant and flowing waters (4% of correct answers).

Chart 5 data show how students solve tasks at the highest levels of knowledge.

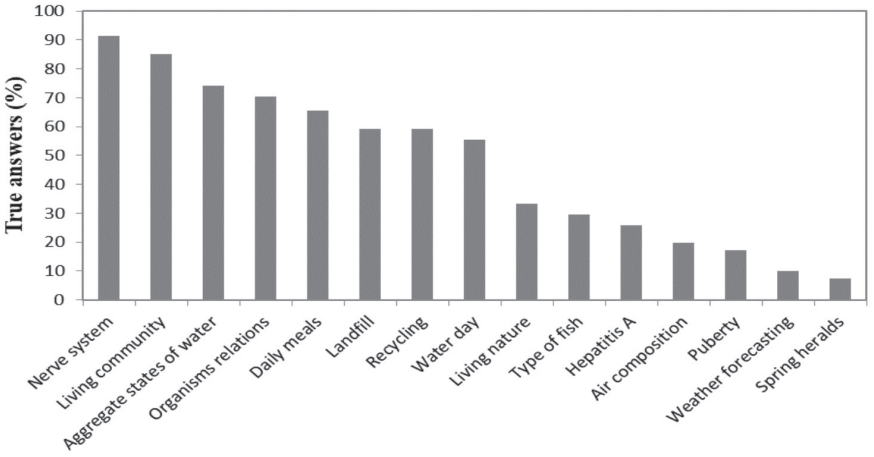

Chart 5. Understanding scientific contents according to the fifth and sixth level of knowledge

The third group of multiple-choice tasks shows that students are most familiar with the parts of the human nervous system (91% of correct answers) and the concept of life community on the example of a lawn (85% of correct answers). They are very good at correlating organisms into food chains and pyramids (70% of correct answers) and at determining daily meals (65% of correct answers). They are good at determining the order of actions to take during waste disposal (59% of correct answers) and recycling (59% of correct answers). As many as 56% of students connect the date of the Water Day and the celebration of Water Day among other important dates linked to the environment. Students are extremely poor at determining which fish belongs to the group of oily fish (30% of correct answers), as well as determine how hepatitis B is transmitted (26% of correct answers). Students do not determine the composition of air to a satisfactory extent (20% of correct answers). The same was noticed when it comes to determining the year when puberty starts for both girls and boys (17% of correct answers). Most students answered that puberty starts after the 11^{th} year of age. An extremely small number of students knows how to separate spring flowers from other plants which also grow in spring (7% of correct answers).

Therefore, the hypothesis (H4) assuming that students are worst at solving questions linked to species in homeland areas and their distribution into habitats of our country is accepted.

3. CONCLUSIONS AND IMPLICATIONS

The results obtained by the analysis of natural science concepts knowledge show that the level of knowledge of natural science concepts is at an unsatisfactory level, which leads to the conclusion that the level of students' motivation for a better understanding of nature, living beings in ecosystems, human body structure and eventually human activity has to be raised.

In general, students achieved better results at first and second level of knowledge questions than at other levels, which implies that it is necessary to set tasks at higher level of knowledge during lessons.

This research results could help the educational orientation of future teachers. The subject course Natural Science should be enriched with workshops and field teaching. In such a way students could better understand the wild life in various ecosystems of the Republic of Croatia. Moreover, it is necessary to procure teaching aids (models of the human body) for students to investigate the position and parts of certain human organic systems. Subjects courses following Natural Science and linked to natural science literacy should be correlated from one semester to the next, and in the final year the subject course Methodology of Science and Social Studies Teaching could be held. It is necessary to suggest an elective subject course in the final study year linked to the research approach which is the base of the subject curriculum of the subject Science and Social Studies. The students' suggestion after the research was to incorporate the science and social studies materials from primary teaching into the subject course Methodology of Science and Social Studies Teaching through seminar papers, as well as to go into more depth with the materials to better understand and know scientific contents. In such a way they would be able to better train pupils to correlate the subject Science and Social Studies with everyday life and environment. Moreover, it would be useful to align programmes and courses conducted at all teacher studies in the Republic of Croatia.

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POZNAVANJE PRIRODOSLOVNIH POJMOVA BUDUĆIH UČITELJA

SAŽETAK

U ovome je radu ispitano poznavanje prirodoslovnih pojmova kod budućih učitelja (N = 132). U tu je svrhu priređen upitnik s pitanjima iz udžbenika prirode i društva. Pitanja iz kognitivne domene su svrstana u tri skupine: 1. skupina (1. i 2. razina ishoda: navesti, označiti, imenovati), 2. skupina (3. i 4. razina ishoda: klasificirati, sortirati, odabrati) i 3. skupina (5. i 6. razina ishoda: povezati, procijeniti i odabrati). Rezultati istraživanja pokazuju nisku razinu poznavanja prirodoslovnih pojmova (51% točnih odgovora). Studenti najbolje rješavaju zadatke prve skupine (69%), a potom treće (48%) i druge (38%) skupine. Kod studenata se uočavaju problemi u razvrstavanju biljaka i životinja koje žive u tekućicama, stajaćicama i moru. Vrlo malo studenata prepoznaje proljetnice među ostalim biljkama koje cvatu u proljeće. Rezultati ovih istraživanja mogu pomoći u samoevaluaciji znanja samih studenata. Da bi se postigla odgovarajuća razina prirodoslovne pismenosti studenata učiteljskoga studija, a time i učenika, dane su preporuke za njezin razvoj u okviru programa učiteljskoga studija.

Ključne riječi: obrazovanje budućih učitelja, nastava prirode i društva, prirodoslovno znanje, ishodi učenja, prirodoslovlje.