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PRE-SERVICE PRIMARY TEACHERS' SCIENCE CONTENT KNOWLEDGE: A CASE OF LITHUANIA

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Abstract

Primary school teachers' science competence remains a highly relevant theoretical and practical problem. Although the general curricula and educational standards of Lithuanian general education school set quite high requirements for the process of primary school science education, the science competence of teachers raises reasonable concerns. It has to be stated that in university primary education study programmes, insufficient attention is paid to the natural science component. This leads to a possible lack of preparation for pre-service primary school teachers in science education.

A pilot study conducted at the beginning of 2020, in which 107 students from two Lithuanian universities participated, showed that their scientific knowledge was poor and insufficient. Particularly weak was subject knowledge from the field "Nature research", and also knowledge related to animate and inanimate nature. An assumption can be made that science literacy of pre-service primary education teachers is not sufficiently developed at university, which is one of the factors limiting the quality of children's science education. There are probably two main reasons for this situation: insufficient science education in general education schools, and insufficient training of students in the field of science education for pre-service primary school teachers.

Keywords: *quantitative research, pilot research, pre-service teachers, science content knowledge, university students*

Introduction

Primary science education is formed in primary school. The development of students' science competence is inseparable from teachers' science competence, an integral part of which are subject, didactic, and managerial abilities (Lamanauskas & Augienė, 2012). It is obvious that in order to understand the peculiarities of science education working with younger children (6–12 years), exhaustive research is needed and on the basis of it, science education in primary school has to be modelled, adjusted and developed (Lamanauskas, 2003; 2009). According to researchers, the teaching of science at the primary level is of world-wide concern (Lloyd, et al., 1996).

A significant number of teachers think that they are not competent enough in science education (Morgan, 2012). Systematic integral science training is especially important for primary school teacher, they must have sufficient knowledge of biology, physics, chemistry, engineering and technology, ecology, etc. (Lamanauskas & Makarskaitė, 2000). Although primary school teachers assess personal competence in science education quite favourably, however, they consider it insufficient (Laurukėnaitė & Makarskaitė-Petkevičienė, 2003).

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A study conducted in 2001 found that in all Lithuanian universities that train primary school teachers, natural science preparation of final year students is insufficient. In particular, they lack methodological skills, and have little knowledge of science education experience in foreign countries (Lamanauskas, 2001). The other research studies reveal similar tendencies. It is said that primary school teachers usually lack enough science content knowledge (Appleton, 2003). A study conducted in Estonia showed that student teachers' PCK consist more pedagogical knowledge than knowledge of science (Timostsuk, 2015). The latter research studies also claim that primary school teachers are commonly known to have low self-efficacy in mathematics and science (Catalano et al., 2019). Teacher's content knowledge is a critical component in teaching (Lewthwaite & MacIntyre, 2003), to ensure teacher's work effectiveness (Robinson, 2017).

Science education in primary school is not only important but also problematic. The importance lies first and foremost in the fact that science education is an integral part of general education (Lamanauskas, 2008). The 2015 National Student Achievement Survey report states that "it is necessary to be concerned about the quality of science and social education in primary schools and to increase the percentage of fourth-graders, who reach the highest levels of cognitive achievement in the world" (2015..., 2015). Thus, the main goal of science education is students' science literacy. The aim is for students to know the basic natural science concepts and conceptions, the specifics of methods, to develop the ability to reasonably evaluate natural science application possibilities and limitations. Natural science education must not only help the student get to know animate and inanimate nature world, but also encourage them to ask, suggest ideas, think critically; prove that scientific conclusions are based on clear evidence. Students should realise that natural sciences and their development help to create a productive and ecologically balanced world. Natural science learning should develop student's confidence in the face of constant change, the ability to make responsible decisions and help to become an active citizen.

It follows that preparation of pre-service primary teachers in the field of science education remains extremely relevant and significant. Science knowledge is an important part of their general competence. Complete and systematic research is needed on the basis of which primary school teachers' preparation and further training could be improved. It is obvious that there is a dearth of research addressed to study how to improve teacher's knowledge of science content (Verdugo et al., 2016; Martin-Raugh, et al., 2018). The aim of the study was to evaluate pre-service primary school teachers' science content knowledge. An assumption is made that the level of knowledge is insufficient, and the information obtained will be useful for the improvement of teacher education programmes in universities and colleges.

Research Methodology

General Background

Research was carried out in January-March 2020. Research type was diagnostic. The research was grounded on a quantitative social research paradigm, holding the attitude that educational diagnostics allows evaluating rather accurately the analysed

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features. The researchers were holding an opinion that a pilot study is a small sized study which may be used before larger scale study of any type.

Sample

The study involved 107 students from two Lithuanian universities, pre-service primary school teachers. A convenience sampling which is one of non-probability sampling procedures was used. Such sample is considered sufficiently representative for the pilot research (Viechtbauer, et al., 2015). The sample of the study consisted of students, therefore the distribution of subjects according to gender is not presented.

Table 1
Respondents' Distribution

Course	*N*	%
The first	48	44.9
The second	27	25.2
The third	9	8.4
The fourth	23	21.5
Total	107	100.0

Students participated in the survey voluntarily. Prior to the study, the purpose of the study was explained to them, and the respondents were informed about the confidentiality of the study.

Instrument and Procedures

The questionnaire used in the study consisted of 30 closed-ended questions. Each question had 4 possible choices, of which only one was correct. According to Jarrett et al. (212), multiple-choice instruments are suitable for data collection in educational surveys. The original instrument was used in the study (Verdugo et al., 2016). The researchers' consent was received by e-mail to use the instrument, including certain application recommendations. The questionnaire was translated from English into Lithuanian and later back into English. Two researchers independently of each other ensured the validity of the translation. An English language expert participated in the translation validity assessment.

An evaluation of the validity of the content of the research instrument was performed. In this regard, the general curriculum of primary science education was analysed, as well as other documents related to the curriculum. The basics of science education in Lithuanian primary schools are integrated with the basics of social education in the course "World cognition" This course is implemented all four years (grades 1-4 of primary school). The content of science education includes: a) nature research; b) animate nature (biology); c) substances and their variations (chemistry); d) physical

phenomena (physics) (General Programs..., 2003). Two university lecturers, primary education experts, conducted an analysis of all 30 questions of the research instrument. It was found that they fully fit the Primary school curriculum in Lithuania.

Table 2

Areas of Scientific Knowledge in the Research Instrument

Questions in the instrument	Main subject areas involved in primary science in Spain	Equivalence of the field of knowledge in Lithuanian general education programmes
1 - 7	Natural environment and its conservation ("Environment")	Nature research
8 - 15	Biological diversity ("Life")	Animate nature (biology)
16 - 24	Health education and the human body ("Health")	Animate nature (biology) + integrated health education programme
25 - 30	Matter and energy ("Energy")	Substances and their variations (chemistry) Physical phenomena (physics)

Thus, the analysis of the content of the curricula revealed that the issues of the research instrument fully fit the Primary school curriculum in Lithuania.

The survey was conducted in the usual way, by submitting questionnaires to the respondents. Completed questionnaires were returned to the respondents. There were no damaged or incomplete questionnaires.

Data Analysis

For the obtained data analysis, the measures of descriptive statistics i.e., absolute and relative frequencies, were applied. According to separate areas of knowledge, the average frequency of each was calculated as a percentage based on the correct answers. The average of percentages is the true average of a set of two or more percentage values.

Research Results

The analysed answers of the respondents are presented in table 3. Not only the results of the correct answers are presented, but also the incorrect answers.

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Table 3
Students' Science Content Knowledge

Question	Correct answers, N (%)	Incorrect answers, %
1. What is the movement of the Earth around the Sun called?	Revolution, 24 (22.4)	Rotation, 64.5 Precession, 12.1 Circumference, 0.9
2. How long does it take the Moon to orbit the Earth?	28 days, 51 (47.7)	365 days, 26.2 21 days, 13.1 7 days, 13.1
3. Climate is…	The meteorological features occurring in a specific region over a long period of time, 50 (46.7)	The meteorological conditions produced by changes in atmospheric pressure, 39.3 The set of atmospheric phenomena occurring in a specific time and place, 13.1 The condition of the atmosphere for a short period of time (less than 30 days), 0.9
4. Which of the following statements is correct?	Rocks are made of minerals, 56 (52.3)	Minerals, like marble and granite, are very useful for construction, 32.7 Minerals are made of rocks, 8.4 Rocks have a low value for human beings due to their limited applications, 6.5
5. What kind of device is used for measuring wind speed?	Anemometer, 21 (19.6)	Barometer, 54.2 Weathercock, 25.2 Pluviometer, 0.9
6. What is the name given to the groups formed by gas, interstellar dust and thousands or millions of stars?	Galaxies, 65 (60.7)	Constellations, 23.4 Nebulas, 9.3 Planetary systems, 6.5
7. What part of a volcano is the conduit?	Pipe by which magma flows up, 76 (71.0)	Orifice connecting volcano to the exterior, 15.0 Rocks and solid material formed when lava gets cold, 9.3 Underground pool where magma resides temporary, 4.7
8. Which of the next animal groups are invertebrates?	Insects, 64 (59.8)	Amphibians, 30.8 Fishes, 9.3
9. Living things can be arranged in levels of complexity. When some tissues co-work to perform the same function, what do they form?	Organs, 36 (33.6)	Apparatus, 50.5 Interwoven systems, 9.3 Molecules, 6.5

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10. What is the vital function of flowers in plants?	Reproduction, 77 (72.0)	Respiration, 15.9 Interaction, 10.3 Nutrition, 1.9
11. In addition to water and sun, what gas do plants need to carry out the photosynthesis?	CO_2 (carbon dioxide), 58 (54.2)	O_2 (oxygen), 39.3 CO (carbon monoxide), 4.7 N_2 (nitrogen), 1.9
12. What is the name given to the leaves that form the calyx of a flower	Sepals, 57 (53.3)	Petals, 27.1 Stamens, 15.0 Corolla, 4.7
13. What is the function of phloem in a plant?	Carrying elaborated sap from the leaves to the rest ofthe plant, 21 (19.6)	Carrying raw sap from the roots to the rest of the plant, 47.7 Absorbing water and mineral salts from the soil, 26.2 Absorbing rays from solar light, 6.5
14. What biological kingdom do viruses belong to?	No kingdom, 45 (42.1)	Protista, 24.3 Monera, 22.4 Fungi, 11.2
15. Which of the following statementsabout differences between plant cells and animal cells is correct	Plant cells contain organelles called chloroplasts that animal cells do not, 79 (73.8)	Plant cells do not have cellular membrane and animalcells do, 12.1 Animal cells have mitochondria and plant cells do not, 10.3 There are no differences. All living organisms are made up of the same cells, 3.7
16. Where is the exchange between $O_2$and CO_2 produced in the respiratory system?	Pulmonary alveoli, 69 (64.5)	Bronchi, 12.1 Trachea, 12.1 Bronchioles, 11.2
17. Which organ is responsible for filtering the blood to remove waste substances?	Kidneys, 53 (49.5)	Liver, 43.0 Urinary bladder, 7.5
18. Which blood component has thefunction of carrying oxygen?	Red cells, 44 (41.1)	White cells, 22.4 Plasma, 18.7 Platelets, 17.8
19. What is the name given to the cellsresulting from fertilization?	Zygote, 73 (68.2)	Ovule, 17.8 Gamete, 10.3 Spermatozoon, 3.7
20. Most nutrients pass into the blood in...	The small intestine, 51 (47.7)	The stomach, 29.9 The large intestine, 16.8 The oesophagus, 5.6
21. In the excretory system, what ductconnects to the outside of the body?	Urethra, 15 (14.0)	Ureter, 44.9 Anus, 35.5 Urinary bladder, 5.6
22. Which organs form the central nervous system?	The brain and the spinal cord, 79 (73.8)	The cerebrum, the cerebellum and the medulla oblongata, 14.0 The sensory and motor nerves, 7.5 The cerebrum and the cerebellum, 4.7

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23. Which organ produces bile?	Liver, 18 (16.8)	Pancreas, 71.0 Stomach, 10.3 Small intestine, 1.9
24. What nutritional substances, present in cereals and legumes, provideus with energy?	Carbohydrates, 69 (64.5)	Proteins, 31.8 Lipids, 2.8 Mineral salts, 0.9
25. Which of the following methods would you use in order to separate a solid from a liquid in a heterogeneous mixture?	Filtration, 60 (56.1)	Distillation, 26.2 Crystallisation, 15.0 Magnetisation, 2.8
26. What is the bending of light rayscalled when they pass from a fast medium to a slower one?	Refraction, 66 (61.7)	Diffraction, 20.6 Reflexion, 11.2 Attenuation, 6.5
27. Which of the following statementsabout renewable energy sources is correct?	They are considered inexhaustible energy sources, 49 (45.8)	Thermal solar energy is an energy source that generates electricity by means of photo-voltaic solar panels, 39.3 They are at present time the most common energy sources, 15.0
28. What kinds of changes modify the composition of matter?	Chemical changes, 76 (71)	None. Matter does not change, 12.1 Physical changes, 11.2 Biological changes, 5.6
29. What characteristic of sound tells us the difference between a high sound and a low sound?	Pitch, 82 (76.6)	Timber, 13.1 Intensity, 7.5 Volume, 2.8
30. What colour would be obtained if all the colours of the rainbow were mixed?	White, 40 (37.4)	Black, 42.1 Red, 17.8 Yellow, 2.8

Analysing the respondents' answers to the questions in the first area (1 - 7 questions), it can be seen that the percentage only to three out of seven correct answers exceeded 50. The worst result was the answer to the question "What kind of device is used for measuring wind speed?". Only 19.6% of respondents gave the correct answer. The largest share (54.2%) answered that it was "a Barometer", which is designed to measure atmospheric pressure.

Assessing the respondents' knowledge according to the second area (questions 8 - 15), the results were slightly better. The percentage of correct answers to 5 questions out of 8 exceeded 50. The worst knowledge was relatively related to animal and plant anatomy and morphology. Only 19.6% of respondents answered correctly to the question "What is the function of phloem in a plant?". Nearly a quarter of respondents attributed the viruses to the kingdoms of Protista and Monera.

Analysing students' answers to the questions in the third area (questions 16 - 24), it can be seen that their knowledge of human body and health is insufficient. Only the percentage of correct answers to 4 out of 9 questions exceeded 50. The worst answers were to the question "Which organ produces bile?". Only 16.8% of students gave the

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correct answer. The largest share of respondents (71.0%) indicated that bile was produced at the pancreas. The same also can be said about the question "In the excretory system, what duct connects to the outside of the body?". Only 14.0% of respondents gave the correct answer.

Students' knowledge in the fourth area (questions 25 - 30) was the best compared to other areas. The percentage of correct answers to 4 out of 6 questions exceeded 50. The worst results were observed in the answer to the question "What colour would be obtained if all the colours of the rainbow were mixed?". Only 37.4% of students answered this question correctly. Similarly, i.e., as insufficient can be evaluated students' knowledge about renewable energy sources. Only 45.8 of respondents gave the correct answer.

The fourth table summarises the results according to the correct answers provided.

Table 4

The averaged percentage of correct answers by content knowledge areas

The first area (1-7)	**The second area** (8-15)	**The third area** (16-24)	**The fourth area** (25-30)
45.8	51.0	48.9	58.1

It can be clearly seen that students' science knowledge is poor. The best results are demonstrated in the fourth area, the worst – in the first. On the other hand, no final generalisations can be made, but the overall situation is quite clear. In each of the areas, there are questions that were answered correctly by the majority of respondents (the percentage of the correct answers exceeds 70). On the other hand, it is becoming clear that there are clear gaps of scientific knowledge.

Conclusions and Implications

The main research aim was to assess science content knowledge in pre-service primary school teachers. The results show that natural science knowledge is clearly poor and insufficient. The analysis of answers to some questions highlighted possible and serious pre-service teachers' misconceptions in science content. It can be stated that the best expressed area is "Substances and their variations", and the worst is "Natural research" area.

Although the study has several limitations (small sample, no detailed analysis of wrong answers), the results still indicate the need to review primary school teacher preparation programmes. Preliminary analysis of study programmes shows that little attention is paid to the natural science component (natural science competence formation).

The development of specific subject knowledge (how to use it in specific educational situations) becomes especially important. In Lithuania pedagogical skills are separated from subject knowledge, even in competence development events, the formation of pedagogical skills often takes place without a specific content of the subject. Such access just limits the management of subject knowledge, the transfer in specific situations. A similar situation is observed in the training process of primary school teachers.

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