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DEVELOPMENT OF SCIENTIFIC CONCEPTS ABOUT AIR IN EARLY SCINCE EDUCATION

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Abstract: Air is one of the first terms that students encounter in primary science classes. On the other hand, environmental problems of air pollution are present in the daily life of many people, and environmental awareness is developed and nurtured at all levels of education. Air is omnipresent in the lives of children from the earliest age, but due to its invisibility and intangibility, there are difficulties in understanding and adopting the concepts of air and its physical properties. Hence, these difficulties were the subject of this research. The aim of the research was to evaluate the level of adoption of teaching content about air among students in lower grades of primary schools, as well as, to assess whether and to what extent the teaching of the subjects The World Around Us and Nature and Society affects the development of concepts about air. 140 students of lower grades (I-IV) of two primary schools participated in the research. A knowledge test of twelve tasks related to scientific facts about air and its properties was applied. The obtained results show that there are no statistically significant differences in the level of adoption of tested scientific terms depending on the class (age), which points out to the conclusion that the process of developing certain scientific terms about air is insufficiently effective in the initial teaching of natural sciences. It is recommended to apply some innovative teaching models and strategies when processing teaching content about air, and to connect this content to everyday phenomena and students' experiences as often as possible.

Keywords: development of scientific concepts, natural sciences, classroom teaching, air.
Field: Social sciences

1. INTRODUCTION

Child's notions on natural phenomena develop long before they start their formal education. Base initial natural sciences teaching relies on experiential knowledge, thus making school learning possible and meaningful to a student (Blagdanić, Radovanović, Bošnjak Stepanović, 2019). There are several arguments due to which both preschool and junior school age children should be exposed to natural sciences: Children naturally enjoy observing and thinking about nature; exposing students to science develops positive attitudes towards science; early exposure to scientific phenomena leads to better understanding of the scientific concepts studied later in a formal way; the use of scientifically informed language at an early age influences the eventual development of scientific concepts; children can understand scientific concepts and reason scientifically; science is an efficient means for developing scientific thinking (Eshach & Fried, 2005).

The task of teaching, within the educational system, reflects in the need to build a system of concepts in particular scientific areas, to enable students for abstract thinking and further knowledge acquisition, facilitating individual sciences learning through subject teaching (Antonijević, 2000). In common for almost all teaching subjects is that their content, to a greatest extent, relates to developing concepts, and mastering those concepts and the relations between them is a precondition to knowledge acquisition and thinking development (Pešić, 1995). Learning natural sciences is a gradual process during which the initial conceptual structures based on children's interpretations of everyday experience are continually being enriched and restructured (Vosniadou & Ioannides, 2006). The purpose of The World around Us and Nature and Society subjects' teaching is reflected in enabling the students to consider and interpret natural and social phenomena, they will encounter in everyday life, in a proper manner. Teacher's role is to organize child's naïve ideas into coherent concepts that are exact and explicit (Pine, Messer & St. John, 2001).

Concepts are a basic driving force behind child's intellectual development; they occupy the central spot in developing cognitive structures and opinions. Teaching that enables acquirement of scientific concepts have to be individualized and in correlation with the development level of a student (Klausmeier, 1985). It is well established that children explain the world arround them in a manner that is acceptable to

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them, and that, prior to starting school, they already possess, and further during their education, continue to adopt numerous false ideas (misconceptions) about scientific contents featured in the curriculum (Pine et al., 2001; Dimitriou & Christidou, 2007; Balać, Bošnjak Stepanović, Bogdanović, 2022; Blagdanić, Radovanović, Bošnjak Stepanović, 2019). There are plenty of sources for developing misconceptions and the most emphasized are: Children's experiences, ignorance of the elders (parents and teachers) and influence of peers. Children's misconceptions are deeply rooted and change resistant (Milanović Nahod and associates, 2003), therefore, it is necessary to identify them on time and correct them in a timely manner. Conceptual tests are one of efficient ways to detect misconceptions.

2. MATERIALS AND METHODS

The goal of the research was to determine the acquisition of the concepts about air in students in the lower grades of elementary school, as well as, to establish whether and to a what extent the teaching classes influence the development of the scientific concepts. The basic initial assumption was: The process of developing particular scientific concepts about air in the classroom teaching is insufficiently efficient. Based on the basic assumption, the subhypothesis was also defined: It is assumed that there are no differences in the level of acquisition of particular scientific concepts in relation to the grade (age) of students.

The research sample consisted of 140 students of the first, the second, the third and the fourth grade from two elementary schools, and the research itself was conducted in autumn 2020. A descriptive (when describing the occurrences and concepts during the theoretical part of the work) and an analytical method (when analyzing the results that were obtained upon collecting data during the research) were used in the research. An empirical non-experimental method was used, along testing as a research technique. A knowledge test consisted of 12 tasks that related to the scientific facts about air and its characteristics (Table 1). By analyzing the metric characteristics of the test, a moderate reliability of the instruments was determined (Cronbach's alpha, α), which was 0.598. A dependent variable was represented by the quality of knowledge on acquired concepts about air expressed in scores for each individual test, and totally, on the entire test. That variable was quantative and continual, while the independent variable grade (age) was categorial. For the purpose of determining the efficiency of the teaching of the subjects The World around Us and Nature and Society, the achievements of the participants were checked using the test with 12 tasks on the concept, characteristics and significance of air.

Table 1. Overview of concepts, demands and number of points scored on the test on knowledge about air

Ordinary number	Concept	Request	Number of points
1.	Air as a life condition and an energy source	Circle the illustrations that show beings, things or objects that cannot live, exist or operate without air (displayed are: a fish, a girl, a sunflower, a bird, a giraffe, a TV, the Sun, a windmill and a jacket).	4,5
2.	A plant – a source of oxygen	Explain why it is said that plants are “oxygen factories“.	2
3.	Presence and visibility of air	The picture displays a glass with straws and air bubbles. Explain why blowing into straws produces bubbles in a glass with water.	3
4.	Wind is an air movement	Explain in your own words what wind is.	2
5.	Behavior of air when heated and cooled	The picture shows an empty bottle with a balloon on the top of the bottle and two dishes, one containing hot and the other ice cold water. Write what would happen when the bottle is inserted into hot, and what when it’s inserted into ice cold water. Explain what can be concluded from that experiment.	3
6.	Oxygen supports combustion	The picture shows a lit candle and a jar above it. Write what will happen to the candle flame if we cover it with the jar. Explain what can be concluded from that experiment.	4
7.	Characteristic s of air	Three claims are offered (Air is all around us. Air has a color. Plants use air to breathe). Circle if the claim is true (T) or false (F).	3
8.	Sources of air pollution	Cross out the drawings that show polluters and circle those that do not (offered are the following illustrations: a car, a bus, a factory, a bicycle, a deodorant, an electric car)	3
9.	Air can be felt while moving	The pictures show a child in front of a fan, a tree in the wind and a child on the swing. Based on those illustrations, list when air can be felt.	6
10.	The role of air in plant reproduction	A picture shows seeds of dandelion and maple in the air. Based on the picture, explain how air helps plant reproduction.	3
11.	Pressure air	A picture shows a glass filled with water, with a lid made of a thin paper and turned upside down. Using the picture, explain why water did not pour out of the glass.	2
12.	Air is all around us	Circle the illustrations that show environments where air is present (offered are: an ocean, Space, a house, land, a volcano, a hole in a tree, a balloon, an empty bottle, a cave).	4,5

General success achieved on the test was presented using a scale that measures the level of achievement via score intervals, while the percentage of correct answers, as a variable, was categorized in 5 levels (Table 2). The pupils had limited time to complete the test (45 minutes), with an opportunity to score a maximum of 40 points.

Table 2. Test score board scale

Points	Percentage of correct answers (%) and categories
0 – 8	0 – 20 (1)
9 -16	21 – 40 (2)
17 – 24	41 – 60 (3)
25 – 32	61 - 80 (4)
33 – 40	81 -100 (5)

To process the obtained results, the following statistical methods were used: analysis of contingency tables (Chi-square test) and the procedure of a One-way univariate analysis of variance (ANOVA).

3. RESULTS

The analysis of contingency tables, with aim to test the independence of two category variables, was used to check the research subhypothesis that among the students of different levels of education there are no statistically significant differences in term of test scores, i.e. in term of results categories they belonged to. As shown in Table 3, there was no statistically significant connection between the levels of education (grades) and the test achievement category (χ2 = 10.817, p = 0.288). Although statistically significant differences were not obtained, the presence of certain score results within various levels of education (grades) can be analyzed, in order to evaluate a general trend in test achievements. It was demonstrated that scores of none of the participants belonged to the category 1 (0-20% of correct answers), while the greatest percentage of scores belonged to the category 4 (61-80% of correct answers) – a total of 90 students (64.3% of the total sample). Within that category, the most numerous were the second grade students (35 i.e. 38.9% in total). The second most represented was the category 5 (81-100% of correct answers) that counted 29 students (20.7% of the total sample), and most of them were also the second grade students (11 i.e. 37.9%).

Table 3. Connection between grade (age) and test achievement category

			LEVEL OF EDUCATION						
			First grade	**Second grade**	**Third grade**	**Fourth grade**	**Total**	χ^2	**p**
ACHIEVEMENT CATEGORY	2 (21%-40% of correct answers)	f	0	1	0	2	3	10.817	0.288
		p(%)	0	33.3	0	66.7	100		
	3 (41%-60% of correct answers)	Total	2	7	3	6	18		
		p(%)	11.1	38.9	16.7	33.3	100		
	4 (61%-80% of correct answers)	Total	21	35	18	16	90		
		p(%)	23.3	38.9	20	17.8	100		
	5 (81%-100% of correct answers)	Total	2	11	6	10	29		
		%	6.9	37.9	20.7	34.5	100		
Total		Total	25	54	27	34	140		
		p(%)	17.9	38.6	19.3	24.3	100		

To check the subhypothesis that there were statistically significant differences between the students of various levels of education (grades) in terms of total scores for every of the 12 test questions, a One-way univariate analysis of variance was used. A level of education variable (with the categories of the first, the second, the third and the fourth grade) was used as an independent variable, while a total score on individual question variable was used as a dependent variable. Within the Table 4, a difference in achievements per each individual question was displayed, depending on the level of education (grade) of the student.

Table 4. One-way analysis of variance of the differences in test achievements between students in four age categories per questions

Task	Grade	Number of pupils	Arithmetic mean (M)	SD	F test	p
1.	I	25	4.14	0.339	1.122	0.343
	II	54	4.06	0.401		
	III	27	3.89	0.684		
	IV	34	4.03	0.627		
	Total	140	4.03	0.518		
2.	I	25	1.46	0.691	0.693	0.558
	II	54	1.58	0.649		
	III	27	1.72	0.669		
	IV	34	1.54	0.711		
	Total	140	1.58	0.674		
3.	I	25	2.88	0.415	2.306	0.079
	II	54	2.79	0.698		
	III	27	2.48	1.042		
	IV	34	2.43	1.045		
	Total	140	2.66	0.844		
4.	I	25	1.32	0.497	1.518	0.213
	II	54	1.21	0.588		
	III	27	1.37	0.582		
	IV	34	1.44	0.269		
	Total	140	1.32	0.513		
5.	I	25	1.72	1.137	1.950	0.124
	II	54	1.41	1.236		
	III	27	2.00	1.143		
	IV	34	1.94	1.391		
	Total	140	1.71	1.255		
6.	I	25	3.32	1.249	3.455	**0.018**
	II	54	3.52	1.094		
	III	27	3.78	0.641		
	IV	34	2.82	1.714		
	Total	140	3.36	1.271		
7.	I	25	2.88	0.332	1.755	0.159
	II	54	2.83	0.376		
	III	27	2.70	0.465		
	IV	34	2.91	0.288		
	Total	140	2.83	0.372		
8.	I	25	2.94	0.166	1.358	0.258
	II	54	2.84	0.398		
	III	27	2.81	0.282		
	IV	34	2.73	0.539		
	Total	140	2.83	0.392		
9.	I	25	4.96	2.091	0.326	0.806
	II	54	4.89	1.929		
	III	27	4.67	2.075		
	IV	34	4.53	1.988		
	Total	140	4.77	1.987		
10.	I	25	2.82	0.659	3.064	**0.030**
	II	54	2.89	0.492		
	III	27	2.89	0.577		
	IV	34	2.47	0.969		
	Total	140	2.77	0.695		
11.	I	25	0.32	0.945	1.531	0.209
	II	54	0.70	1.409		
	III	27	0.89	1.281		
	IV	34	1.03	1.403		
	Total	140	0.75	1.320		
12.	I	25	3.50	0.979	1.261	0.290
	II	54	3.50	0.707		
	III	27	3.72	0.594		
	IV	34	3.73	0.448		
	Total	140	3.60	0.695		

An analysis of variance has demonstrated statistically significant differences between the students in different grades (age) only in questions six ($p= 0.018$) and 10 ($p= 0.030$). In addition, post-hoc tests have revealed that statistically significant differences were present only between the second and the fourth grade students. The achievements in the remaining ten questions did not obtain any statistically significant differences.

In order to check whether statistically significant differences existed in the answers to tasks that consisted of several segments (tasks 1, 7, 8, 9 and 12), a contingency table analysis was performed. Within the task 1, the chi-square statistics elucidated significant difference only in the windmill option ($\chi 2 = 8.671$, $df = 3$, $p = 0.034$), where the fourth grade pupils were more successful than others, i.e., a significant majority of them circled the windmill as an object that cannot operate without air. Out of three claims in the task 7, false answers occurred only in the third (Plants use air to breathe), and it was equally represented in all grades. Upon reviewing the chi-square statistic of the task 8, a statistically significant difference between the participants from various grades was observed only in the case of identifying a deodorant as an air polluter ($\chi 2 = 10.496$, $df = 3$, $p = 0.015$), where, unexpectedly, younger students (the first and the second grade) achieved better scores than the older ones (the third and the fourth grade). In the task 9, out of three ways to feel the air (a fan, wind and a swing), students in all grades were the least familiar with the fan, which can be attributed to increase use of air conditioner instead of fans. Within the task 12, the students were asked to circle all pictures of the environments, objects and things that have air inside them, and statistically more significant differences were determined for the ocean option (compared to all other, incorrect answers dominating with the second grade pupils) and land (the second grade pupils had significantly more incorrect answers), while the volcano option was equally confusing to everyone.

4. DISCUSSIONS

With insight into representation of certain categories on the test of knowledge about air, depending on the grade (age), it was noticed that there were no results in the category 1, i.e., that all participants answered more than 20% of questions correctly. On the other hand, the largest percentage of results belonged to the categories 4 and 5, which means that a significantly large portion of students (64% and 21% respectively, in total 85%) gave correct answers to more than a half of test questions. Within these two categories, the most numerous were the second grade students, what could be, to a large extent, a consequence of their greatest participation in the sample. Additionally, it was observed that a portion of the results in the category 3 was small, while in the category 2 was almost neglectable (i.e. only 15% of participants had scores in those two categories). Based on previously mentioned, it is evident that knowledge test scores of students of all grades were rather high. The analysis of the contingency tables with the aim of testing the independence of two category variables (level of education – four grades and knowledge test achievement – five categories) confirmed that there was no statistically significant connection between them, which was in accordance with the defined subhypothesis.

Using One-way univariate analysis of variance of achievement on each of the 12 tasks of knowledge test obtained statistically significant differences only within the tasks 6 and 10, and only between the second and the fourth grade students. Analysis of answers to the tasks that contained several segments (tasks 1, 7, 8, 9 and 12) showed that in windmill option of the task 1 the fourth grade students were more successful than others, while in the task 8 the younger students (grades 1 and 2) obtained better scores that the older ones (grades 3 and 4) while recognizing a deodorant as an air polluter. These results are in correlation with the research findings that confirmed that younger pupils most frequently answer the questions based on their intuition and experience, while older ones often balance between their intuition and school knowledge (Thompson & Logue, 2006). In contrast, in the task 12, statistically significant differences were established for ocean and land options between the second grade students (scored worse) on one hand, and all the others on the other. Presence of air in volcanoes seemed less possible to students of all grades, as well as the facts that plants used air to breathe (task 7) and that air can be felt using a fan (task 9). Bearing in mind that the achievement of the participants in all four grades were rather unified and that certain misconceptions were identified, a basic subhypothesis according to which the process of developing particular scientific concepts about air in the classroom teaching is insufficiently efficient can be accepted.

5. CONCLUSIONS

Analysis of the students' achievements on the knowledge test has revealed that the process of developing particular scientific concepts about air, influenced by the teaching of the subjects The World around Us and Nature and Society from the grade 1 to 4, was insufficiently efficient. Namely, besides generally good overall success achieved in all grades (most students had achievements in the categories 4 and 5), a lack of statistically significant differences between the achievements of participants from different grades in almost all tasks indicates a negligible influence of teaching. We assume that a more frequent use of innovative methods and strategies of teaching and learning would increase that influence. Furthermore, individual research work of the students and the correlation of school contents with everyday occurrences and children's experiences would contribute to overcoming the observed false ideas, as well as many other misconceptions about air.

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