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Ecological Literacy of Pupils of Primary Education in Slovakia as a Precondition of Biodiversity Education

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Abstract: Children who are currently in primary schools are part of the generation that will be most affected by the current environmental trend of our planet in the future. They are the generation that will need to live in accordance with sustainable development and biodiversity protection. One of the key aspects of biodiversity education is to increase environmental literacy using appropriate and effective methods. Our aim was to assess the ecological literacy of a group of primary school students in Slovakia and to identify areas where additional support and clarification may be needed for effective biodiversity education. Our findings reveal widespread misconceptions regarding terms such as 'ecology,' 'community,' 'population,' and 'ecosystem.' The research emphasizes the importance of innovative pedagogical approaches to address and correct these misconceptions effectively. By incorporating exploration-oriented teaching methods, hands-on activities, and a constructivist approach, educators can engage students in experiential learning and facilitate a deeper understanding of ecological principles. Interdisciplinary and participatory research approaches focused on biodiversity education offer promising avenues to enhance ecological literacy. Moreover, increasing interest in environmental education can contribute to nurturing environmentally conscious individuals equipped to tackle ecological challenges effectively. This study underscores the urgency of prioritizing ecological education at primary schools and provides insights into strategies for fostering ecological literacy among young learners.

Keywords: *Biodiversity education, ecological misconceptions, environmental stewardship, experiential learning.*

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Introduction

The environmental crises of recent decades have already attracted media and public attention for their obviousness. Dramatic problems, especially in the individual living and non-living parts of the natural environment, are closely monitored, although the ecological perspective of the environment as a whole piece is often overlooked (Dahlan, 1994; Magno, 1996).

School is the primary site for shaping individuals' perspectives on science, society, and ecology. The formation itself takes place through environmental education, which is therefore needed at all levels of education, from pre-school to university (Domka, 2004; Potter, 2009). The main goals of environmental education are to inform people about the environment and to increase positive attitudes towards it (Farmer et al., 2007; Fernández-Manzanal et al., 2007). Environmental education is not merely a subject content that is to be taught; rather, it is a way of thinking and behaving (Davis, 1998).

Children currently receiving primary education are part of the generation that will be most affected by the current environmental trend of our planet in the future. The upcoming generation will need to prioritise sustainable development aimed at biodiversity protection as a necessity, rather than just an attitude. In their future professions, these children will also have to look for solutions to the challenges and consequences that are rooted in today's behaviour in society (Boeve-de Pauw & Van Petegem, 2011). One of the possibilities for making it easier for them is to transform present-day behaviours through changes in the education of the current and future generations of children. In order to help pupils better understand these issues, the primary school curriculum generally includes basic knowledge about biodiversity, as well as positive thinking in favour of sustainable development (Wilson & Monroe, 2005), including in Slovakia (National Institute for Education and Youth, 2015).

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Biodiversity education is also emerging together with its attributes leading to sustainable development. Its attributes are applicable to education (Miranda et al., 2016; Navarro-Perez & Tidball, 2012) and can be described as a process-oriented, participatory, and action-oriented learning approach that emphasises the critical role of biodiversity in our ecosystem (Tilbury & Calvo, 2005; Wiegelmann & Zabel, 2021). Pupils and students generally agree on the importance of biodiversity conservation and the benefits it provides to humanity.

However, research shows that pupils and students often have misconceptions or incomplete views on biodiversity, including the classification of living organisms, their diversity and hierarchies, and difficulties in understanding the concept of biodiversity itself (Braund, 1991, 1998; Id-Babou et al., 2023; Morón-Monge et al., 2021; Navarro-Perez & Tidball, 2012).

Biodiversity education operates at three levels. Firstly, it encourages personal experience and appreciation of nature through direct contact. Next, it increases ecological literacy, i.e., the ability to analyse the relations that exist between the various species in our ecosystem and the position of humans within the ecosystem. Last but not least, biodiversity education involves a kind of nature policy, formed by a discussion about the fair distribution of natural resources and an understanding of the impact of policies and treaties. To be effective, biodiversity education needs to operate at all three levels, increasing ecological literacy, building relationships with the environment at a local level through direct experience, and applying this knowledge at a global level by understanding the complexity of relationships. Therefore, children today need to be effectively educated (for example in groups and actively participating in learning processes) about the biology and ecology of species to achieve sustainability on our planet (Jeronen et al., 2017).

Ecology education is thus crucial in an era of global change and biodiversity loss worldwide (de Brito Miranda et al., 2017; Nehm, 2019). In fact, a proper understanding of the biology of a species also requires an understanding of the complexity of relationships in individual ecosystems as well as within the planet. It is essential not only for scientific knowledge but also for the broader public and children to develop their ecological literacy. Especially, looking at how organisms are interdependent in terms of nutrition acts as a precursor for learning about such biological topics as food chains, species evolution, and natural selection (White, 2000). However, interactions between species in an ecosystem are not well understood by students (Bermudez et al., 2017) and sometimes even by teachers (Sweeney & Sterman, 2007). There is even a clear link between misconceptions present in pre-service teachers' knowledge base and those dominant in students (Butler et al., 2015).

Calls for early ecological education have been driven by a growing concern that children in developed countries are spending an increasing amount of time indoors, leading to a lack of interaction with the natural world and hindering the development of appropriate biological concepts and positive attitudes towards the local environment (Dankiw et al., 2020; Fjørtoft, 2004; Wells, 2000). Moreover, ecology, which is typically studied within the field of biology, deals with complex theoretical concepts that are challenging for students to learn thoroughly due to the abundance of relationships between ecological concepts. As a result, students often resort to memorization, even at the primary education level (Toman, 2018).

Despite the inclusion of environmental education in the education system in Slovakia with the aim of promoting sustainable development, environmental education often focuses only on waste management or the protection of specific locally important or endemic species. As a result, general biodiversity education is lacking, or some of its essential attributes are not maintained. Currently, however, there is an ongoing curricular reform in Slovakia, through which it is possible to improve the current direction of education in the country. It is necessary to clearly document the current state, especially for the most sensitive age categories. In the country, the absolute majority of the educational institutions consists of state schools with unified education system, so it is necessary to identify only the differences in some aspects such as gender differences or proximity to nature in terms of rural and urban living. In this study, we focused on one aspect of biodiversity education, namely ecological literacy among a group of primary school children in Slovakia. The reason for choosing primary school children was the importance of having correct and especially comprehensive information at an early age. Also, as already mentioned above, these children are the generation that will be most affected by the current environmental trend of the Earth and will have to make corrections based on a comprehensive educational foundation based not only on knowledge of organisms, but also on the complex relationships in ecosystems. Thus, the aim was to assess their level of knowledge and understanding of basic ecological concepts such as animate and inanimate nature, community, food chains, ecosystem, or biosphere, as accurate knowledge about living organisms is crucial for developing relationships and bonds with them.

Methodology

To assess the level of knowledge and understanding of basic ecological concepts, we conducted a quantitative study using the didactic test method in printed form. The pupils were given a time limit of about one lesson (about 40 minutes) to complete the test. Prior to that, the pupils had been informed about the nature, process, and subject of the research. We had explained the entire test to all the teachers from different classes that we visited personally, so that they could explain the assignment to the pupils in case of questions and ambiguities.

In the survey, we followed the method of a didactic test on basic ecological concepts. Considering that the test was designed for pupils of younger school age and that it was a test of entry knowledge, we tried to adapt it as much as possible to the age of the pupils. For this reason, the test included matching tasks, a large amount of pictures, but also open-ended tasks with a short answer, multiple-choice closed-ended question tasks, and two-level tasks. We tried to formulate the tasks clearly and comprehensibly so that the pupils would understand them. The face validity of the questionnaire was conducted with an ecology teacher at the university and subsequently with primary school teachers as well, in order to comply with the standards for this area within primary education. Individual questions exhibit local language specifics, but we will attempt an approximate interpretation:

1. Underline what belongs to the forest ecosystem.

This question aimed to determine whether pupils understood the concept of an ecosystem and knew what constitutes an ecosystem. We were also interested in whether they would include both living and non-living components in their answer. In this question, pupils could underline a total of eight correct answers.

2. The biosphere is: (select the correct answer).

In this question, based on the aforementioned studies, we assumed that pupils associate this term more with organic farming or healthy eating. Therefore, we included these options in our choices.

3. Match what belongs to living and non-living nature.

In the third question, we assessed pupils' knowledge about living and non-living nature. Slovak pupils deal with this topic in every grade at the primary level, so we expected high success in this task. However, we anticipated that pupils might classify dead components of nature as abiotic.

4. Natural communities consist of (three options to choose from, each containing three components).

In question number 4, we focused on communities. With this question, we wanted to find out if pupils know what components make up individual communities. In their textbook (until 2022, there was only one approved textbook available), it is stated that a community is "a certain natural grouping formed by plants and animals." We assumed that most pupils would correctly identify these two components but not the third one (fungi). Previous studies also suggest that pupils might confuse the terms community and ecosystem, thus include non-living components of nature (we indicated soil and clay).

5. Identify what the images in each row have in common (each row had 4 images). Write two more examples that could belong there. Give a detailed explanation in the row.

The fifth question also focused on ecosystems. We included forest, lake, marine, and field ecosystems in this question. We were interested to see if pupils would have difficulty identifying the field ecosystem (or distinguishing it from a meadow) and if they could differentiate between a lake and a river ecosystem.

6. Arrange the food chain using numbers (images of individual components with a box for the number below).

The focus of this question was on the food chain. Pupils had already encountered this topic, so we expected higher success in solving it. It was an interdisciplinary question assessing mathematical competencies as well. Pupils had to identify four food chains from field, forest (2), and marine ecosystems; two from domestic environment and two from exotic settings.

7. In the box, there are various animal populations (a total of 19 different images with domestic animals like sheep, ducks, and chickens).

With this question, we aimed to determine whether pupils understand the term "population" and what they associate with it. It was divided into two parts; in the first part, pupils had to colour the circle with the same colour for animals of the same population (7a). In the second part, they had to identify which population in the assignment is the largest and circle its members (7b).

8. Choose from the options, what does ecology study?

The options provided, besides the correct one, included nature conservation and pollution, health and the environment, and global warming. We were particularly interested in whether the pupils would distinguish this term from nature conservation, which is often confused with it.

9. Underline what belongs to the Biosphere.

The last question was again focused on the biosphere. The options were rhinoceros, spruce, Earth's core, beach, Mars, fly agaric, lava, moss, ocean, and bacteria. In this question, students could score a total of 7 points. However, on average, they only scored 2.7 points. As shown in the previous question focused on this concept, students rarely understand this phenomenon well. The reason may be that many students have not yet encountered this concept, or they have only heard about it marginally. The results in the individual categories did not differ significantly.

Overall, we were interested in the total number of points for all the questions, not just individually, based on which we subsequently determined the influence of other observed factors such as age, school, or gender.

The Cronbach's alpha of the questionnaire was .682, which has some limitations, but considering the sample size, the occurrence of dichotomous answers, and the number of questions, we consider the questionnaire to be reliable.

The research was conducted in January of the school year 2021/2022. Pupils were informed in advance that this was not a graded test, primarily to ensure that pupils would not be worried about possible failure and would work independently. The tests were completed and handed in by the pupils during the class. The tests were then evaluated, and the results were processed by means of statistical methods.

Two primary schools, differing in size, number of pupils, and location, took part in the research. The school with the largest number of pupils was located in a medium-sized city in the north of Slovakia (Ružomberok; City). At the time of the research this school had 17 classes at the lower primary school level (1st – 4th grade) with 662 pupils attending. The school also included classes for talented pupils, who also participated in our research. 65 pupils from this school participated in the research, specifically, pupils from one 3rd grade class (Cit3) and three 4th grade classes (Cit4A, Cit4B and Cit4C). The other school that participated in our research was a rural primary school (Village), located 8 km from the town. This school had 6 classes at the lower primary school level, and 42 pupils from this school participated in the research, specifically pupils from two classes of the 3rd grade (Vil 3A, Vil 3B) and one class of the 4th grade (Vil 4). The age of the pupils ranged from 8 to 11 years, with the largest number being 9-year-old pupils.

We used the STATISTICA 13 program to process the obtained data. To evaluate and determine the degree of relationship between two variables, we used correlation analysis. To identify significant differences among multiple variables, we used ANOVA analysis after confirming normality of the variables. We also used the LSD post-hoc analysis in some cases of multiple variable analysis.

Findings/Results

Overall Evaluation of Responses to Individual Questions

In the didactic test, pupils scored an average of 34.5 points out of a total possible score of 52. The best-answered question was question No. 6, which focused on the correct ordering of different representatives of the food chain. The worst-answered question was question No. 8, in which pupils were asked to define what ecology deals with (Table 1; where the average values of points scored by all respondents, as well as the minimum and maximum values, with the maximum values also representing the maximum possible number of points are provided. Relative average values are added for better comparison of the level of answering individual questions).

Table 1. The Total Score and the Number of Points for Each Question Scored by Pupils After Answering the Research Test

Question	N	Average	Min	Max	SD	Relative average
1	107	6.5	0	8	2.16	0.81
2	107	0.4	0	1	0.48	0.36
3	107	8.2	2	12	2.37	0.69
4	107	0.5	0	1	0.50	0.47
5	107	4.8	0	8	2.13	0.60
6	107	10.3	0	12	2.94	0.86
7a	107	0.7	0	1	0.47	0.67
7b	106	0.4	0	1	0.49	0.41
8	107	0.1	0	1	0.33	0.12
9	107	2.7	0	7	2.10	0.39
Total	107	34.5	2	52	7.18	

Comparison Based on Gender

Depending on the gender category, we found a greater average success rate among girls than boys (Fig. 1). In the didactic test, girls scored a total average of 35.1 (SD=7.50) points, while boys scored an average of 34.0 (SD=6.86, Table 2). However, the difference between boys and girls was not statistically significant (p= .45).

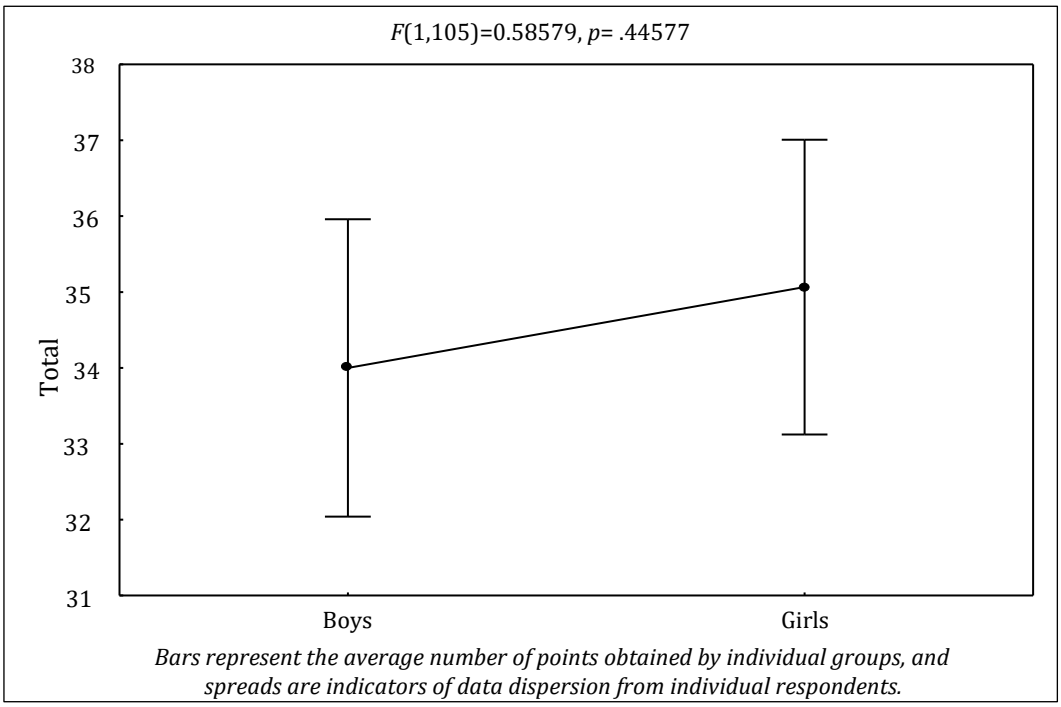

Figure 1. Comparison of the Average Score by Gender

Table 2. The Number of Points for Each Question Scored by Boys and Girls After Answering the Research Test

Question		**1**	**2**	**3**	**4**	**5**	**6**	**7a**	**7b**	**8**	**9**
Sex	**N**	**Average**									
	107	6.5	0.4	8.2	0.5	4.8	10.3	0.7	0.4	0.1	2.7
Boy	53	6.7	0.5	8.1	0.4	4.6	9.6	0.7	0.3	0.1	3.1
Girl	54	6.3	0.3	8.3	0.5	5.1	10.9	0.7	0.5	0.1	2.4
Significance		ns	ns	ns	ns	ns	*	ns	*	ns	ns

Comparison Based on Age

We also examined differences between individual grades at the lower primary school level. Pupils in the 3rd grade scored an average of 33.3 points, while pupils in the 4th grade scored an average of 35.5 points (Fig. 2). Thus, when examining the results of the didactic test, we observed a slight increase in the achieved scores; however, this difference was not statistically significant ($p = .13$). Conversely, the correlation between the total score and age was significant (Fig. 3, $p = .04$).

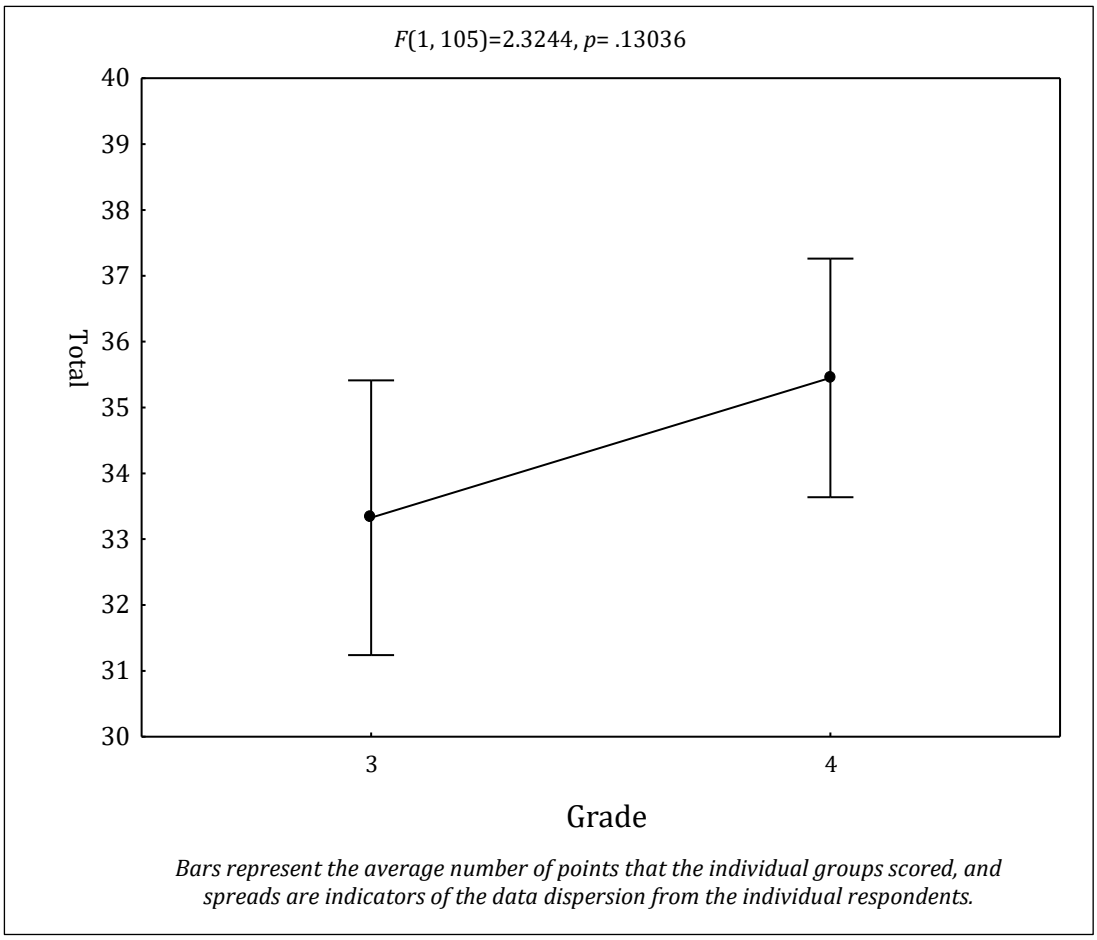

Figure 2. Comparison of the Number of Points Scored in the Grade Category

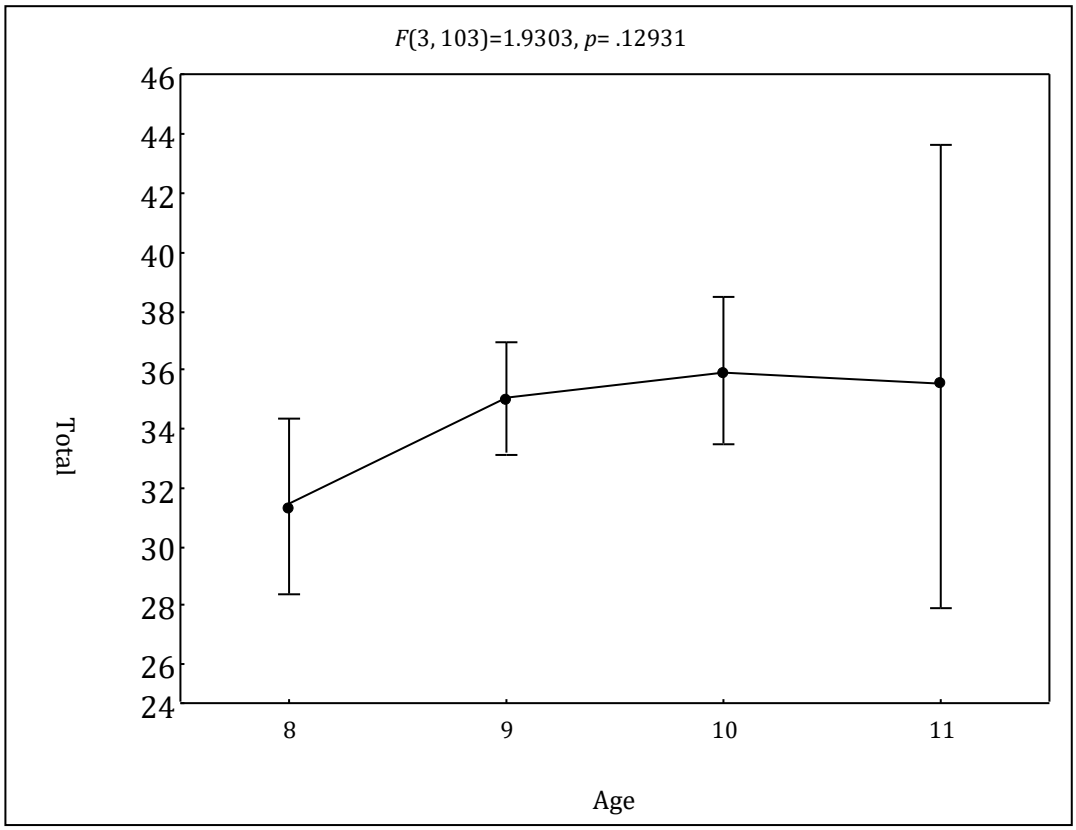

Figure 3. Increase in Pupils' Knowledge of Ecological Contexts in Relation to Age.

Comparison Based on Schools (Areas)

We also looked in more detail at the results of the individual schools and classes where the research was conducted, thereby also monitoring the local impact on the knowledge of the pupils. We observed a significant variation between the 3rd grade classes, with a clear outlier of Cit3A. However, this difference was expected due to the presence of some talented pupils in the class (Fig. 4).

We found a significant difference between the schools ($p < .001$). The rural school (Village) scored an average of 31.6 points, while the school in the city (City) scored an average of up to 36.4 points.

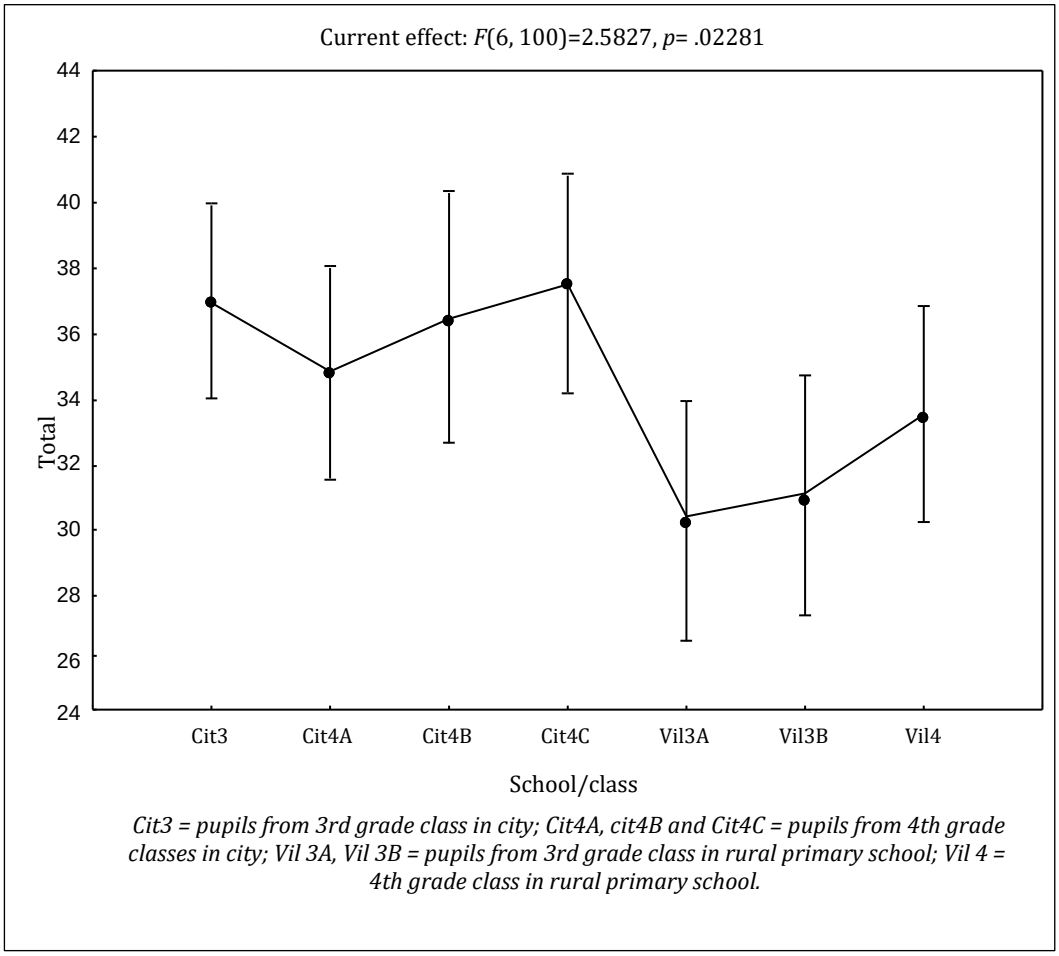

Figure 4. Comparison of the Number of Points Scored in the Class and School Categories, with the Distinct Differentiation of Individual Types of Schools, while the Classes Reflect the Trend Similar to That of Age

Discussion

Ecological Literacy

From an early age, it is important to develop ecological literacy to form individuals' attitudes towards sustainability and fair prospects in economic, ecological, and social spheres. Children construct knowledge through interactions with other people and the environment in which they live. The knowledge they generate is not a copy of reality but the result of an intense process of creation (de Brito Miranda et al., 2017). Particularly at an early age, children develop ideas that include a lot of inaccurate information, and their view of the world around them may be distorted. In Slovakia, research on primary school pupils' perceptions and knowledge of basic ecological contexts is relatively rare. This may be due to the overall low representation of some parts of this topic in the primary school curriculum, where terms such as population, ecosystem, or biosphere do not appear at all. Sometimes, even the translation of ecological scientific theory into the school curriculum can be problematic (Derman & Gurbuz, 2018; Franz, 2001).

In our research, pupils scored 34.5 out of 52 total possible points. They were familiar with some of the terms and understood their meaning (e.g., food relations), but many of the terms and concepts we investigated were difficult for the pupils to understand. Based on previous research that revealed several misconceptions in the field of ecology (Pavlátová, 2019), we were not surprised by the overall outcome of the research. However, we did expect a higher success rate on some questions, especially with terms (e.g., ecology and community) that pupils had already encountered during the

lessons. In particular, in the task that focused directly on the concept of 'ecology' (question No. 8), we observed a very low success rate, with only 12% of children answering correctly, while the majority of pupils thought that ecology deals with the protection of nature and its pollution. The reason for this might be that the term 'ecology' has long been, and still is, mistakenly used just in connection with environmental pollution or waste recycling (Leach et al., 1996; Robles-Piñeros & Tateo, 2021) or in general in connection with lifestyles beneficial to nature.

Understanding complex relationships in ecosystems is also very difficult, particularly because dynamics differ from one context to another. Consequently, students need to be taught how to apply ecosystem-related concepts to different contexts (Hokayem et al., 2015). In addition, education in this area in Slovakia seems to be ineffective, as children did not understand even the terms they had encountered relatively recently at school. However, the ongoing curricular reform is an opportunity to remedy this area, thanks to its preference for inquiry-based education. Its effectiveness, however, will not be apparent for several years.

Food Chains

One of the most complex relationships, and necessary for life on the planet, is food. Plants and animals need to obtain energy to maintain life. Plants get energy and can produce their own nourishment. Animals cannot follow this process and must get energy from external sources, that is, by eating plants and other animals. This quest for survival results in the food chain, represented by the meeting and interconnection of various chains to form a food web. Samples of schoolchildren have been found to have frequent misunderstandings about food chains, often continuing early understandings of simple food chains that often remain unchanged into adulthood (Sander et al., 2006). However, many times pupils mistakenly perceive the trophic pyramid, which depicts the food relationships that take place in the ecosystem, with the food pyramid, which depicts the components of food according to their nutrient content (Pavlátová & Kroufek, 2018). The reason is also the great similarity of these two names in the original Slovak language. Pupils also often believe that organisms higher up the food chain consume everything in the lower food chain (Allen, 2014). Some pupils believe that there are more herbivores than carnivores in nature due to human breeding, rather than differences in energy availability across the food chain. They often include only the first-order consumers in food chains and overlook the role of producers (Leach et al., 1996). Moreover, they may assume that carnivores are more energetically valuable and stronger than herbivores, and are typically large and predatory, while herbivores are perceived as smaller and passive (Gallegos et al., 1994). In our research, since we worked with younger children, we only focused on the correct ordering of the representatives of the food chain (question No. 6). The pupils managed this task the best of all, scoring 10.3 out of 12 points on average. The most common mistake occurred in the second food chain, where they misidentified the predator as a great anteater instead of the North American jaguar. This mistake can be attributed to the fact that the anteater may be unfamiliar to some of the pupils.

Community and Population

In Slovakia, in particular, the term "community" is also problematic. Only 47% of respondents answered correctly when they were asked to identify what belongs to the community. Many times, the pupils marked the answer where the land, plants, and animals belonged. The textbook of natural science (there is only one approved textbook in Slovakia) states that a community is "a certain natural grouping made up of plants and animals" (Wiegerova, 2013). Therefore, we assume that majority of pupils correctly identified these two components but did not know the third one (fungi). The research results also suggest that pupils may confuse the concepts of community and ecosystem, as they also included an inanimate nature component in the community. Pupils perceive the concept of community more holistically, and thus include the abiotic component of nature in it. The problem may also be that in the Slovak language, this word has multiple meanings. Pupils often do not associate it with ecology but with social sciences, in connection with a certain group of people, friends, or family. Some pupils even relate the term to the Lord of the Rings trilogy (Pavlátová & Kroufek, 2018). Sometimes they also understand it as more plants in one place, or many times they do not perceive the difference between a community and a population (Pavlátová, 2019).

Multiple meanings also occur with the term population, and pupils often think of it as just a number, expressing the number of people living in a country or on the planet. We used a two-level task (question No. 7a, No. 7b) to investigate how well the children understood the concept of population. In the first part of the task, in which pupils had to colour animals of the same population, the percentage success rate was 67%. Some pupils coloured only animals of the same developmental stage with the same colour, while others identified, for example, a pulley of a domestic hen, a domestic hen, and a rooster as a separate population. In the second part of the task, where they had to identify which population was the largest, the percentage success rate was lower. Only 40% of the respondents correctly identified the largest population.

What Lives?

Our participants should have had a better understanding of the concepts of animate and inanimate nature, as Slovak pupils always deal with these terms since the 1st grade of primary schools. Therefore, they are familiar with these concepts and know them well. In our research, the overall average success rate for question No. 3 was only 8.2 out of 12

points. For example, pupils were most often mistaken in classifying leaves as inanimate nature. A widespread misconception is that dead organisms are not biotic simply because they are no longer alive (for example, a leaf, a hair, or a bone), becoming a part of inanimate nature. There is also the idea that humans are not a part of the environment and, therefore, not a part of living nature (Shepardson, 2005).

Ecosystem and Biosphere

Another problematic concept in ecology is the concept of ecosystem. Even if pupils are familiar with this concept, it is difficult for them to visualise it. They cannot understand the interrelationships or connections between all parts of the ecosystem, including its size. We were also interested in whether they would include both living and non-living components when classifying parts of an ecosystem. In this question, the pupils were allowed to underline a total of 8 correct answers, with a total average score of 6.5 points (question No. 1). According to Pavlátová and Kroufek (2018), pupils often forget about the non-living component of the ecosystem. They do not perceive the ecosystem as a functional whole, however as a collection of organisms (Suzuki et al., 2015); on the other hand, some pupils believe that the ecosystem provides inexhaustible sources of energy for unlimited population growth (Munson, 1994). Also, pupils often did not underline leaves in our research. This could have been caused by the fact that our research was conducted in an area with primarily spruce forests and, therefore, few deciduous trees. However, this could have also occurred because the research was carried out at a time of the year when the leaves were falling off the trees. We also chose specific ecosystems, and the pupils were asked to identify the type of ecosystem, explain their answer, and add two other components of this ecosystem (question No. 5). Specifically, we chose forest, lake, marine, and field ecosystems. The biggest problem for the pupils was to recognise the field ecosystem. In many cases, pupils confused it with the meadow ecosystem. Similarly, they had difficulty distinguishing between the lake and the marine ecosystems. Interestingly, pupils often correctly added other components of the ecosystem to the box but were unable to explain or provide poor reasons for their choices. Often, they just gave a general explanation, i.e., it belongs to nature. Pupils could score a total of 8 points for the task, with an average of 4.8 points.

The last research concept was the biosphere. Biosphere is not specifically addressed by lower primary school pupils, but they may still have some idea of the concept. We assume that, as with the term 'ecosystem', pupils usually notice the prefix BIO first, because they are more familiar with it in the context of agriculture or cultivation. Therefore, they may perceive the term as a label for organic farming or the organic food trade. In our research, only 36% of respondents correctly answered the question of what the biosphere was (question No. 2). The most frequently chosen option was "organic farming". The last task (question No. 9) was also focused on the biosphere, asking pupils to choose from the options that indicated what belongs to the biosphere. In this question, pupils could have scored a total of 7 points, but on average they scored only 2.7 points. As shown in the previous question focusing on this concept, pupils' understanding of this phenomenon is still very limited.

Boys Versus Girls

The overall assessment results showed a higher success rate (although not significantly) for girls than for boys. Girls achieved an overall average of 35.1 points, while boys scored only 34.0 points. Boys usually report stronger ability and interest beliefs in mathematics and science (Meece et al., 2006); however, girls are often more attentive than boys when doing schoolwork (Yeung, 2011). In particular, the girls were significantly more successful in answering tasks No. 6 and No. 7b, while it was question No. 7b that could have been left unanswered due to inattention, as it was the second sub-question within task No. 7. Question No. 6, however, has an interdisciplinary character with mathematics, and despite this, girls answered it better. It is also a two-step task, which could have caused boys to be inattentive. On the contrary, boys were much better (although not significantly) at answering task No. 2, which focused on the concept of the biosphere. While 45% of the boys answered correctly, only 28% of the girls did. Girls are significantly more interested in so-called "bio" things, which could subsequently influence the emergence of misconceptions about this term. In higher grades, the biosphere also appears in the curriculum of Earth sciences, where boys generally dominate. The beginnings of these differences can therefore be found already in the primary period.

Rural Versus Urban School

The elementary school located in the village scored less (31.6 points on average) than the school located in the city (36.4 points on average). This result surprised us, as most of the research carried out in Slovakia or in the Czech Republic so far (which has a similar educational system) had shown the opposite outcome. For example, Kvasničák (2011) conducted research at primary schools to analyse pupils' perceptions of the ecosystem. His research showed a statistically highly significant difference in favour of rural schools. However, the difference between the urban environment of a city and its suburban parts and surrounding villages was not very significant. Moreover, some pupils from the surrounding villages commute to schools in Ružomberok city. The direct influence of the countryside is thus disappearing. On the contrary, the city primary school (City) lists several objectives in its school curriculum in the framework of environmental education that may result in a better knowledge of pupils in basic ecological concepts. They aim to contribute to helping pupils to learn the basic rules for behaving in nature with respect to organisms and their environment, to recognise the

main changes in their environment by observing their surroundings, to know and choose specific options aimed at protecting and improving the environment, and to recognise the main characteristics of the different types of the environment. In addition, there are classes with talented pupils in this school, who have also been the subjects of our research. In our research, these could also have contributed to the better results of this school and the results of the individual classes.

Removing the misconceptions themselves (due to their deep roots in the minds and emotions of pupils) is very difficult. If teachers want to bring about a change in the pupils´ knowledge and remove the unsatisfactory conceptions, they must bring about significant conceptual changes to the pupils' knowledge. This means reorganising knowledge that has been acquired incorrectly. In most cases, however, traditional forms of teaching, such as lectures, reading a text, or simple practical exercises, are not sufficient for such a change. That is to say, it is not enough just to embrace new knowledge. The misunderstood concept should be re-examined, flawed knowledge must be identified, and then the misconception must be replaced with the correct understanding (Gooding & Metz, 2011). In the case of ecological concepts, exploration-oriented teaching in nature is particularly effective, especially when it is in line with the biodiversity education principle of personal experience and appreciation of nature through direct contact when 'science can come alive' (Ayotte-Beaudet et al., 2023; Editorial Board, 2006). It is also necessary to use a constructivist method of teaching, for example, by assigning hands-on activities using a research-based approach, because in this way the pupils participate in the formation of knowledge (Cooke et al., 2021). The interdisciplinary and participatory research, resulting in active collaboration through mutual learning and constructivism, and involving science from the children's perspective, provided clear evidence of the engagement of children in understanding basic concepts of biology and ecology associated with biodiversity (Coşkunserçe, 2024; Katili et al., 2021; Miranda et al., 2016). Sometimes, an overall increase in interest in environmental education is sufficient, as can be seen in our research based on the example of the school in the City (Cit).

Conclusion

In conclusion, our research underscores the critical need for enhancing ecological literacy among primary school children, particularly in Slovakia, where gaps in understanding basic ecological concepts persist. The study revealed significant misconceptions among students, especially regarding terms like 'ecology,' 'community,' 'population,' and 'ecosystem.' These misunderstandings highlight the necessity for a targeted educational approach that not only imparts knowledge but also effectively addresses and corrects misconceptions.

Recommendations stemming from our findings emphasise the adoption of innovative teaching methods that prioritise experiential learning and active engagement. Exploration-oriented teaching in natural settings, alongside hands-on activities, can provide children with firsthand experiences that make ecological concepts tangible and relatable. Utilising a constructivist approach, which involves students in the construction of knowledge, is also essential for fostering a deeper understanding.

Furthermore, interdisciplinary and participatory research approaches, coupled with a focus on biodiversity education, can enrich learning experiences and empower students to grasp fundamental ecological principles. Finally, increasing overall interest in environmental education, as demonstrated by the success of schools like the one in the City, can play a pivotal role in cultivating a generation of environmentally conscious individuals equipped with the knowledge and skills needed to address pressing ecological challenges.

Recommendations

As we consider the implications of our findings, it becomes apparent that addressing the identified challenges in ecological education requires strategic interventions and collaborative efforts. The following recommendations emerge from our study as actionable strategies for future researchers and practitioners seeking to enhance ecological literacy among primary school students. By implementing these recommendations, we can work towards fostering a generation of environmentally conscious individuals equipped to address pressing ecological challenges.

To begin with, it is imperative for future researchers and practitioners to focus on developing tailored educational resources that effectively target common misconceptions among primary school students. Innovative pedagogical approaches, including exploration-oriented teaching and constructivist methods, should be explored to actively engage students in the learning process and promote deeper comprehension. Additionally, the integration of experiential learning opportunities, such as field trips and hands-on activities, into the curriculum can provide pupils with tangible experiences that reinforce their understanding of ecological concepts.

Furthermore, biodiversity education should be emphasised within ecological literacy initiatives, highlighting the interconnectedness of species and ecosystems and the importance of biodiversity conservation. Encouraging children to become active participants in environmental stewardship efforts empowers them to take actions that contribute to the protection and conservation of natural resources.

Lastly, providing professional development opportunities for teachers is crucial to enhancing their knowledge and pedagogical skills in ecology education, ensuring they are well-equipped to effectively teach ecological concepts.

Limitations

While our study offers valuable insights into ecological education among primary school students, it is important to acknowledge certain limitations that may impact the interpretation of our findings. These limitations highlight areas where further research or methodological refinements may be necessary to enhance the robustness of our conclusions. By recognising and addressing these limitations, we can strive to provide a more comprehensive understanding of ecological literacy and effectively inform future educational interventions.

Firstly, the research may have been conducted in a specific region or school setting, which could limit the applicability of the findings to other geographic areas or educational contexts. Additionally, external factors, such as changes in curriculum or educational policies, could have influenced pupils' ecological literacy or the context in which the study was conducted. Similarly, the role of teachers in delivering ecological education might not have been adequately explored or controlled for in the study, despite their potential impact on students' understanding of ecological concepts.

Ethics Statements

The studies involving human participants were reviewed and approved by the Catholic University in Ružomberok and Comenius University in Bratislava. The participants provided their written informed consent to participate in this study.

Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Authorship Contribution Statement

Balážová: Conceptualization, design, article acquisition, analysis, writing, critical revision of manuscript, final approval. Ciceková: Article acquisition, writing, critical revision of manuscript. Macko: Critical revision of manuscript, final approval. Záhorská: Conceptualization, design, article acquisition, analysis, writing, critical revision of manuscript, final approval.

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