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THE EFFECT OF PROBLEM-BASED AND INQUIRY-BASED LEARNING ON THE SCIENTIFIC LITERACY OF YOUNGER SCHOOL-AGE STUDENTS IN THE TEACHING OF NATURE AND SOCIETY

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Abstract: Early school age is marked by the introduction of various concepts about the world around us. It is crucial for children to develop clear understandings of these concepts in order to apply them in new situations. Functional knowledge fosters scientific literacy, which is of significant importance for individual development and is emphasized in Nature and Society classes through various teaching models. This study aims to examine the impact of problem-based and inquiry-based learning on scientific literacy in the context of teaching Nature and Society to younger school-age students. The research focused on content related to the planet Earth and Space—topics rich in scientific concepts and highly abstract. A parallel-group experiment was conducted with 224 fifth-grade students from two elementary schools in the Republic of Srpska. One group followed the inquiry-based learning model, another the problem-based model, and a control group was taught using traditional methods. Students were matched by gender, average grade in Nature and Society, and results of an initial test taken at the end of the fourth grade, and were randomly assigned to groups. After a seven-week experimental program, a final assessment was conducted. The results showed that students in both experimental groups outperformed those in the control group, with no statistically significant difference between the experimental groups. The study concludes that both problem-based and inquiry-based learning positively impact scientific literacy, highlighting the need for their wider application in the teaching of Nature and Society. Future research should explore these models across more diverse content areas to better understand their broader applicability.

Keywords: *problem-based learning; inquiry-based learning; scientific literacy; early school age; Nature and Society instruction.*
Field: Social Sciences and Humanities

1. INTRODUCTION

Children's development is significantly influenced by the patterns, situations, and contexts they encounter within the family and peer groups. Starting from the development of motor skills and language, children must learn a wide range of concepts on which they will later build systemic knowledge. Vygotsky (1977) states that even before entering school, children have a concept of certain subjects—they understand the representations these subjects form, though they may not yet be fully aware of the concept itself. These early, spontaneous concepts, as Vygotsky refers to them, are eventually deepened, systematically organized, and defined through verbal descriptions and non-spontaneous actions to become scientific concepts. The development of scientific concepts lays the foundation for acquiring scientific knowledge and, consequently, scientific literacy—the ability to apply this knowledge in new situations and maintain a positive attitude toward science (Pavlović Babić, Baucal, & Kuzmanović, 2009). A scientifically literate person is able to offer scientific explanations for phenomena, design and evaluate scientific research, interpret data, and make informed decisions. Therefore, the goal of science education should be to develop competencies for researching, evaluating, and using scientific information in decision-making and action (OECD, 2025).

Through the teaching of Nature and Society, children become familiar with their natural and social environment, which forms the basis for studying natural and social sciences throughout their schooling. In the Republic of Srpska, the curriculum for primary education (2021) outlines a range of topics, including humans, flora and fauna, transportation, family, geography, celestial bodies, materials, and movement. These topics are introduced during the first five years of primary education. Active learning is a core element of effective science education in the natural sciences (Kanphukiew & Nuangchalerm, 2024), with various teaching methods supporting this approach, such as problem-based learning (PBL), project-based learning, inquiry-based learning (IBL), and STEM education.

Inquiry-based learning is less known, less applied, and less researched in the Republic of Srpska than other models. However, it is closely related to problem-based learning, with both focusing on the development of scientific literacy. This study aims to examine the impact of problem-based and inquiry-

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based learning on the scientific literacy of younger school-age students in Nature and Society instruction.

2. MATERIALS AND METHODS

The study was conducted using an experimental method with parallel groups during the 2023/24 school year, involving 224 fifth-grade students from two elementary schools in the Republic of Srpska. The content covered topics about the planet Earth and the universe—rich in scientific concepts and abstract in nature. The study focused on this content because it is typically introduced for the first time in the fifth grade, making it ideal for exploring the effects of problem-based and inquiry-based learning. To investigate the impact of these two teaching methods, two experimental groups and one control group were formed. The first experimental group studied the material through inquiry-based learning, while the second experimental group used problem-based learning. The control group was taught using traditional methods. Students were matched based on gender, average grade in Nature and Society, and performance on a pre-test administered at the end of the fourth grade. They were then randomly assigned to one of the three groups. The experimental program lasted seven weeks and included lessons on “Celestial Bodies” and the “Origin and Composition of the Earth.” These topics aimed to help students understand key scientific concepts such as stars, planets, meteors, satellites, the Solar System, Earth’s atmosphere, hydrosphere, biosphere, and more.

While problem-based and inquiry-based learning share similar principles, key differences were highlighted during the experiment. In problem-based learning, students were primarily guided by the teacher to solve problems, while in inquiry-based learning, students conducted independent research with minimal teacher intervention. As the lessons progressed, both groups were encouraged to take increasing responsibility for their learning, with the goal of fostering independence and initiative.

The research tested the following hypotheses:

- Main Hypothesis: The experimental program enhances scientific literacy in the teaching of Nature and Society.
- Auxiliary Hypothesis 1: The experimental program will positively influence student performance on the knowledge test.
- Auxiliary Hypothesis 2: No statistically significant differences will exist between the experimental groups on the knowledge test.

Two knowledge tests were used as measuring instruments: a pre-test (administered at the end of the fourth grade) and a post-test (administered after the experimental program). The tests assessed content areas related to scientific literacy and were validated based on their alignment with the prescribed curriculum outcomes (2021). The reliability of the tests was high, with Cronbach’s alpha values of 0.75 (pre-test) and 0.89 (post-test). Sensitivity was verified through the Kolmogorov-Smirnov test, which showed no statistical significance. Objectivity was confirmed with a Pearson correlation coefficient of 0.99, indicating consistency between examiners.

The sample of respondents was balanced by gender (114 boys, 110 girls), average grade in Nature and Society, and pre-test performance. After the experimental program, a final assessment was conducted, and the results were analyzed using ANOVA, LSD, and t-tests.

3. RESULTS AND DISCUSSION

In accordance with the research hypotheses, the existence of differences and their statistical significance between the experimental groups and the control group in terms of achievement on the final test, as well as the differences in achievement among the experimental groups themselves, were examined.

After statistically significant differences were found across all questions of the final test, according to ANOVA (with a significance level of $\rho \leq 0.05$), the LSD test was applied to determine which groups benefited from the observed differences in responses to each question of the final test (Table 1).

Table 1. Differences in achievement between the control group and the experimental groups

Question	MEA	Sig.	MEA	Sig.
	K – E1		K – E2	
1	-1.62	0.000	-1.76	0.000
2	-1.21	0.000	-0.99	0.000
3	-0.65	0.000	-0.30	0.027
4	-1.87	0.000	-1.17	0.000
5	-0.29	0.000	-0.23	0.002
6	-0.43	0.000	-0.48	0.000
7	-1.01	0.000	-0.86	0.000
8	-2.51	0.000	-2.72	0.000
9	-.022	0.017	-0.28	0.002
10	-1.55	0.000	-1.47	0.000
11	-0.63	0.000	-0.58	0.000
12	-0.37	0.006	-0.52	0.000
13	-1.87	0.000	-2.13	0.000
14	-0.55	0.000	-0.77	0.000
15	-1.43	0.000	-1.61	0.000
16	-0.25	0.002	-0.30	0.000
17	-0.33	0.000	-0.40	0.000
18	-0.28	0.001	-0.33	0.000
19	-2.03	0.000	-2.25	0.000
20	-0.63	0.000	-0.64	0.000

Legend: MEA – maximum extreme difference between the expected and obtained distribution; K – control group; E1 – first experimental group (inquiry-based learning); E2 – second experimental group (problem-based learning); Sig. – statistical significance of the differences between the groups.

Source: Authors' research

The differences in achievement between the control group and the first and second experimental groups were statistically significant for each question, given that the significance level was $\rho \leq 0.05$, and none of the differences exceeded this threshold. A negative sign in front of the reported differences indicates that the advantage is in favor of the second group, i.e., in favor of the experimental groups.

Table 2. Differences in achievement between the experimental groups

Question	MEA	Sig.
	E1 – E2	
1	-0.14	0.474
2	0.26	0.201
3	0.35	0.054
4	0.40	0.180
5	0.05	0.523
6	-0.05	0.655
7	0.16	0.492
8	-0.21	0.343
9	-0.06	0.567
10	0.08	0.701
11	0.06	0.727
12	-0.15	0.324
13	-0.26	0.273
14	-0.22	0.131
15	-0.18	0.455
16	-0.06	0.514
17	-0.08	0.388
18	-0.06	0.530
19	-0.22	0.317
20	-0.01	0.948

Legend: MEA – maximum extreme difference between the expected and obtained distribution; E1 – first experimental group (inquiry-based learning); E2 – second experimental group (problem-based learning); Sig. – statistical significance of differences between groups.

Source: Authors' research

Certain differences in responses between the experimental groups were observed (Table 2). In some questions, the differences favored one group, and in others, the second group (as indicated by the sign of the MEA value). However, these differences were not statistically significant, as the p-values exceeded the ρ ≤ 0.05 threshold (ranging from 0.054 to 0.948). These results confirm that students in the experimental groups achieved approximately the same results and did not differ significantly in their performance on the final knowledge test.

Table 3. Differences in the achievements of the groups on the final testing

Group	F	t	df	Sig. (2-tailed)
E1 - K	3.73	14.70	149	0.000
E2 - K	5.85	15.70	145	0.000
E1 – E2	0.09	-1.593	148	0.113

Legend: E1 – first experimental group; E2 – second experimental group; K – control group; F – Levene's test; t – t-test value; df – degree of freedom; Sig. (2-tailed) – statistical significance.

Source: Authors' research

Overall differences among the groups are shown in Table 3. The t-test values for the experimental groups compared to the control group (14.70 and 15.70) were statistically significant in both cases (2-tailed Sig. = 0.000). No statistically significant differences were observed between the experimental groups regarding their achievements on the final test (2-tailed Sig. = 0.113).

Based on these results, it can be concluded that both auxiliary hypotheses were confirmed. Both problem-based and inquiry-based learning positively influenced the quality of knowledge acquisition about celestial bodies, contributing to adequate scientific literacy in this domain. This fully supports the general hypothesis: "The experimental program contributes to the development of scientific literacy in the teaching of Nature and Society."

The quality of problem-based and inquiry-based learning regarding its impact on the development of scientific competencies, interest in studying content, and achievement in natural sciences has also been examined by other authors (Ting Wen et al., 2020; Unlu & Dokme, 2020; Yakobi Kaliun, Ahmad Muslihin, Ahmad Rashid & Abdullah, 2020; Rafafy Batlolone & Franky Souisa, 2020; Nainggolan, Situmorang & Hastuti, 2021; Zhao, He, Liu, Tai, Hong, 2021). Scientific literacy, as argued by Wen, Liu, Chang, Chang, Chang et al. (2020), is a strong predictor of research behavior. Inquiry-based learning can motivate students with different levels of achievement in science, helping them understand the purpose of experiments and research (Wu & Wu, 2011). Such experiences and understanding of science, scientists, and their methods remain relatively stable during the early school years (Bartels & Lederman, 2022). Younger students can explore scientific ideas qualitatively and conceptualize the type of knowledge developed through scientific research (Akerson, Cesljarev, Liu, Lederman, & El Ahmadie, 2023). Problem-solving fosters research competence, improving the quality of education and enabling knowledge transfer (Sulichka, 2024). Radivojević and Gavrić (2023) found that active learning models positively influence students' enthusiasm for acquiring science content. Implementing models such as inquiry-based learning enhances students' attitudes, motivation, sense of responsibility, and environmental values (Unlu & Dokme, 2020). Both learning models support the acquisition of abstract concepts, such as processes in humans, plants, and animals, meteorological phenomena, and the water cycle, highlighting the need to examine these approaches across a broader range of content.

4. CONCLUSIONS

Problem-based and inquiry-based learning are effective approaches in modern science education for younger students, aimed at developing scientific literacy. Both approaches enable students to build knowledge independently. While many studies have examined these models individually or in combination with other teaching methods across various natural and social science topics, this study is distinguished by its comparative examination of the methodological potentials of problem-based versus inquiry-based teaching. The research was conducted in the Republic of Srpska, where inquiry-based learning is relatively unfamiliar. The study aimed to confirm the positive effects of both problem-based and inquiry-based teaching, providing a basis for further research on implementing these models among primary school teachers in the subject Nature and Society.

This subject includes scientific content essential for students, such as plant and animal life, materials, movement, and the human body. In this study, the effects of problem-based and inquiry-based teaching were examined using content on celestial bodies, which is highly abstract for younger students.

Future research could focus on content related to human organ systems. Evaluating the effectiveness of these models across a broader range of topics will facilitate better recognition of their applicability in science education.

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