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COOPERATIVE LEARNING THROUGH NATURE GAMES: A KEY TO PRIMARY SCHOOL DEVELOPMENT IN MATHEMATICS AND ENVIRONMENTAL EXPLORATION—A CASE STUDY WITH A GROUP OF 0-CLASS CHILDREN

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Abstract: The increasing screen time and digital distractions in modern education have underscored the need for innovative approaches to early childhood learning that reconnect children with the natural world. This study investigates the integration of cooperative learning methods in nature within the "Mathematics and Environmental Exploration" (MEE) curriculum, aiming to enhance both mathematical skills and social competencies among six-year-old children. A year-long case study was conducted with a pre-primary class at the German Department of the National College Liviu Rebreanu in Bistrița, Romania. The intervention involved a five-month practical phase, featuring weekly workshops in local parks and forests. These sessions were designed to integrate mathematics with environmental exploration through playful and cooperative activities. Mathematical tests and social skill questionnaires were used to measure the impact of the nature-based games. Results indicated significant improvements in both mathematical understanding and social skills. Post-intervention assessments revealed enhanced problem-solving abilities, a better grasp of mathematical concepts, and increased proficiency in cooperation and teamwork.

children.

Key words: Cooperative learning, nature-based education, pre-primary education, cognitive benefits, environment exploration, play-based learning, social skills development, teamwork and cooperation, Mathematics and Environmental Exploration

1. Introduction

The interconnectedness of humanity and the natural environment underscores the importance of fostering a deep understanding of both mathematical concepts and environmental awareness in early education. As articulated by Wendell Berry, the recognition of our shared dependence on Earth's resources and environment is crucial for cultivating a responsible and integrated approach to education (Luca, 2021). This perspective emphasizes the value of engaging with nature as a means of enhancing cognitive, social, and emotional development, particularly through cooperative learning and nature-based activities.

In an era marked by increasing digitalization, children are spending more time in front of screens, which can lead to overstimulation and a diminished connection with the natural world. The educational framework for Mathematics and Environmental Exploration (MEE) addresses this concern by integrating nature-based learning activities into the curriculum. Research highlights that learning through nature-based games offers a healthy alternative that supports holistic development and fosters crucial skills such as cooperation and problem-solving (Gottschalk, 2019). Cooperative learning in natural settings not only promotes teamwork but also provides opportunities for cognitive engagement and stress reduction.

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The MEE curriculum is designed to build foundational knowledge and skills across several domains: Numbers, Geometric Shapes and Solids, Measurements, Data, Life Sciences, Earth Sciences, and Physical Sciences. This curriculum focuses on developing general competencies, including basic arithmetic operations, geometric recognition, environmental observation, logical reasoning, and data representation (Pleșca, 2022). The article proposes and tests a program aimed at effectively implementing the MEE curriculum. Specific competencies are progressively developed through structured activities that draw on students' concrete experiences and incorporate diverse teaching strategies tailored to various learning styles. We hypothesize that cooperative learning through nature games positively impacts preschool children's cognitive development by enhancing their problem-solving skills and mathematical understanding. Furthermore, participation in nature-based cooperative games is expected to improve preschool children's social skills, including communication, teamwork, and empathy. To explore these effects, we conducted a case study with a pre-primary class, assessing students' social and cognitive skills both before and after the implementation of nature-based cooperative activities.

2. Fundamental principles for developing the intervention program

The intervention concept and most workshop sessions were organized around play and learning through play. The cultural historian Johan Huizinga connects play behavior to the origins of human culture. He defines play as a fine, non-materially interested, not seriously intended activity, performed within certain fixed limits of time and space, according to voluntarily accepted rules, having its goal in itself, and accompanied by a feeling of tension and joy and a consciousness of being different from ordinary life (Huizinga, 1987). It was essential that the students discover nature for themselves through playful activities and cooperate in problem-solving tasks.

Children are naturally curious and learn through play. Their innate curiosity is stimulated by playful exploration, which not only helps adjust their brain structure but also strengthens skills that enable them to be engaged and flexible learners throughout their lives. The transition from play to learning in school involves didactic play, which helps children shift from play to structured learning activities. The structure of an activity based on a didactic game can be divided into several clearly defined phases (Lăzărescu & Ezechil, 2006): organizational moment, capturing attention, formulating objectives and the game's title, updating previous knowledge, directing the learning process, achieving performance objectives and ensuring transfer, ensuring feedback and evaluation, and retention. The implementation includes oral didactic games as well as didactic games with practice materials, either with one material or several, which can be used either centrally or distributed.

In the preschool class, the curriculum for mathematics and environmental exploration emphasizes the development of general competencies. These include recognizing and using numbers in simple calculations, locating and relating geometric elements in the surrounding environment, showing curiosity for phenomena, relationships, regularities, and structures in the nearby environment, generating simple explanations using elements of logic, sorting and presenting data for problem-solving, and using unconventional standards for measurements and estimations (Ministry of Education, Research, Youth and Sports, 2012).

After exploring the defining characteristics of the didactic game and identifying the key competencies to be developed in the lessons for "Mathematics and Environmental Exploration" for zero-grade students, an example of a didactic game is now presented. This game is specifically designed to foster children's curiosity, observation skills, and mathematical abilities while providing an interactive and enjoyable learning experience. The activity "Mathematical Discovery in Nature" aims to develop and promote the participants' counting skills and associating numbers with objects in nature. At the beginning of the activity, which lasts about ten minutes, the participants are explained the purpose of this mathematical discovery. Each participant receives numbered cards from 1 to 10 and bags or baskets to collect the found objects. In the next step, which lasts fifteen minutes, everyone goes together into nature, where the participants search for objects that match the number on their card. This discovery phase allows the participants to find and collect a variety of natural materials such as leaves, stones, or flowers. After collecting the objects, the participants sit in a circle and start counting. Each one shows their collected objects one by one and counts them aloud, showing each object in turn.

This takes about twenty minutes and ends with a discussion about the concept that the number of objects is determined by the last number in the sequence 1, 2, … x, where $x < 10$. After that, the participants share their objects with each other to ensure that everyone can fully experience the numbers from 1 to 10.

Another key component among the workshop sessions is activities in nature. Nature is essential for our lives, impacting everything from our food to our mental health. Natural environments improve attention, efficiency, and overall well-being, with benefits observed in activities like hiking, gardening, and simply being around greenery. Planning for outdoor activities with children involves route planning, time management, appropriate gear, and sufficient refreshments to ensure safety and enjoyment. Nature as a learning environment offers more space and fewer distractions compared to traditional classrooms, allowing children to observe and understand seasonal changes and environmental factors. It is well known that people learn more through action than through mere observation or listening. The more senses are activated during learning, the better we remember information. Nature as a learning environment offers a wealth of stimuli, whether tactile, visual, or auditory. This appeals to the creative side of children and encourages them to become active themselves. Getting active in nature also means "more relationship and resonance through the transformation of things. (...) In doing, not only do things change under the children's hands, but the things also change the children" (Miklitz, 2020, p. 25).

Research by Wood, Bruce, and Baxter (2012) highlights the importance of implementing outdoor learning policies and practices into the current UK curriculum on a more regular basis, emphasizing the benefits for young children's health and physical well-being. They conclude with recommendations for future strategies that outdoor learning providers can adopt to support and enhance children's physical activity outdoors without detracting from their enjoyment, exploration, or play. Additionally, Bartalis (2017) emphasizes the significance of cooperative games in developing language skills through extracurricular activities. Her conception, "Arts educate," underscores that concentration, movement, and perception exercises, as well as games that foster cooperation, build tolerance and group competence. This aligns well with the goals of our intervention, where language development is supported through collaborative and interactive play in natural settings.

Activities in nature also foster self-efficacy; for instance, when children climb a tree or build a lodge, they gain confidence in their abilities. Internal attribution, the process by which children recognize their successes, can be encouraged through initiated reflection or feedback from teachers. Furthermore, moral values related to environmentalism and appropriate behavior in nature are significant. Children learn the importance of respecting nature, such as not disturbing animals in their habitats (Klein, Türk, & Roth, 2018). In collaborative projects, like building a bridge over a runnel, children take on responsibility in social situations, promoting teamwork and ethical considerations regarding their environment.

Furthermore, recent research emphasizes that for cooperative learning to yield successful outcomes, the quality of interactions among students is essential. It was found that the nature of these transactive interactions correlates positively with student learning outcomes during collaborative activities. In a study involving 68 students from various grade levels, typical interaction patterns during face-to-face cooperative learning were analyzed. Groups engaged in solving open-ended mathematical tasks were observed and their interactions coded. The findings indicated a strong tendency for students to validate and engage with correct proposals, signifying effective transactive interactions. However, there was also a notable occurrence of incorrectly confirming erroneous suggestions, as students were less inclined to provide corrections. Despite this, discussions surrounding these incorrect proposals did occur frequently, although they seldom resulted in successful problem-solving. The implications of these findings underline the importance of fostering quality interactions within cooperative learning frameworks in classroom settings (Nemeth et al., 2023).

Ultimately, following rules in nature is essential, as it teaches children about respecting ecosystems and fostering a sense of stewardship for the environment. Practical activities in natural settings are time-intensive and sustainable, engendering intrinsic motivation through tactile experiences and a sense of pride in their accomplishments (Miklitz, 2020). By emphasizing these aspects, the

intervention aims to cultivate well-rounded individuals who are not only proficient in mathematical and social skills but also equipped with moral values and a sense of responsibility toward their environment.

3. Methodology

3.1. Hypotheses and Objectives of the Study

This study posits that participation in nature-based cooperative learning activities will significantly enhance primary school's mathematical understanding and problem-solving skills compared to their pre-intervention levels. Additionally, it is anticipated that engagement in nature games and cooperative learning will improve social skills, including communication, teamwork, and empathy, as evidenced by post-intervention questionnaire results. Furthermore, the integration of nature-based play and cooperative activities is expected to foster emotional development in primary school, contributing to increased confidence and resilience during problem-solving tasks.

The objectives of the study were to guide the implementation of cooperative learning and nature-based activities in primary school education, to organize and execute weekly workshop sessions incorporating cooperative learning activities and outdoor games over a five-month period, to assess the impact of nature-based activities on primary school children's cognitive development, specifically in mathematical understanding and problem-solving abilities, to improve social skills by focusing on teamwork, communication, and empathy, to utilize two research tools (a mathematical test and a social skills questionnaire) to analyze the changes in children's cognitive and social skills before and after the intervention and to encourage collaboration among students through team-based activities, emphasizing the importance of teamwork for their future interactions in the classroom.

3.2. Participants

This study employed a random sample of 20 students from the primary school class of the German Department at the National College Liviu Rebreanu in Bistrița, Romania. Participants were selected with the consent of the school principal and under the supervision of the classroom teacher.

3.3. Workshop sessions

The year-long case study involved a preparation phase, where the theoretical foundation was established, and the intervention was organized and planned; a five-month practical intervention phase, consisting of weekly workshop sessions with cooperative learning activities and outdoor games in the park near the school, and occasionally in a nearby forest; and a post-intervention phase, where the results of children's development were analyzed using two different research methods.

The intervention was designed to harness children's natural curiosity and playfulness to facilitate learning and development. By combining cooperative learning activities with nature-based play, the goal was to enhance preschool children's cognitive, social, and emotional skills. Each workshop session was carefully structured to balance guidance and freedom, creating an environment that encouraged exploration and active learning.

Over the course of five months, the intervention included weekly sessions in the park and sometimes in the forrest. These sessions aimed to foster collaboration and deepen mathematical understanding among the children. The didactic games were crafted to introduce mathematical concepts through hands-on experiences in nature, while simultaneously enhancing teamwork and communication skills. Initial challenges were addressed through post-activity discussions that focused on problem-solving and the resolution of encountered issues. One illustrative activity was "Build a Forest Hut," designed to teach concepts such as stability, balance, and structure. Children used natural resources to construct a forest hut, which involved joining two 1.5-meter-long branches into a V shape and securing them with string. This structure was then stabilized by pressing the branch ends into the ground. After completing the hut, the children added blankets to make it comfortable. This activity, along with others like "The Weather Journey," "Nature Explorers," "Mathematics Discovery in Nature," "The Search for the Tree," "Natural Object Collection and Categorization," "Mathematical Nature Picture

Outdoors," "Counting Elements of Nature," and "The Adventures of the Wheat Seeds - Sowing and Growing Together!," aimed to provide varied and engaging experiences.

The general objectives and specific competencies of these activities were:

1. Identifying phenomena, relationships, regularities, and structures in the immediate environment.
2. Applying numbers in basic calculations.
3. Recognizing geometric properties of objects in the surrounding space.
4. Problem-solving through sorting and presenting data.

All activities were conducted exclusively in teams, with varying group sizes ranging from pairs of two to larger groups of four, six, or even ten, including the entire class working as a single team.

3.4. Research Tools

The project utilized two primary research tools: Mathematics and Environmental Science test and a questionnaire assessing children's social skills. The aim of these tools was twofold: first, to evaluate the children's mathematical understanding and problem-solving abilities, and second, to determine whether nature-based activities contribute to improved cooperation within the pre-primary class. This is a crucial objective, as fostering teamwork and mutual understanding is essential for students who will spend the next four years together.

The mathematics and environmental science test was administered in written form and consisted of five tasks, incorporating both traditional mathematical exercises and problems related to nature and its elements. The students completed the test within approximately one hour. Each task was scored on a scale from 1 to 5. The scores of the 20 students were recorded both before and after the nature-based activities, and the average scores for each task were calculated to assess changes in mathematical understanding and problem-solving abilities.

The mathematics and environmental science test was designed to evaluate various skills aligned with the curriculum objectives (see Table 1).

Table 1. *Tasks of the Mathematics and Environmental Test and Their Purpose*

No.	Task	Objective
1	Draw the today weather.	Observation skills and understanding of weather phenomena.
2	Draw as many elements as the number indicates.	Counting and matching skills.
3	Compare the quantities using these symbols:>(greater than),=(equal to), and <(less than).	Comparison and quantity evaluation skills.
4	Decompose the following numbers.	Skills in handling numbers and their components.
5	Circle the spring elements.	Knowledge about nature and it’s elements.

One of the tasks required students to draw the weather for the day, which aimed to enhance their observation skills and understanding of weather phenomena, reflecting the curriculum’s emphasis on recognizing and relating to environmental conditions. Another task asked students to draw a specific number of elements, which assessed their counting and matching abilities, directly relating to the curriculum's focus on using numbers in simple calculations.

Students were also tasked with comparing quantities using symbols such as greater than (>), equal to (=), and less than (<). This exercise focused on developing their comparison and quantity evaluation skills, essential for understanding numerical relationships as outlined in the curriculum. Additionally,

the test included a task where students decomposed numbers into their component parts, which supported their skills in handling and understanding numbers, aligning with curriculum goals related to numerical operations and structure.

Finally, students were asked to circle elements associated with spring. This task evaluated their knowledge of nature and its seasonal changes, connecting to the curriculum's emphasis on exploring and understanding environmental phenomena. Overall, each task was carefully designed to address specific learning objectives and assess the students' progress in both mathematical and environmental understanding.

The questionnaire assessing children's social skills was administered orally, with participants responding to written questions. The session took approximately five minutes, during which the children answered six questions designed to assess their social skills and cooperative behaviors.

The questionnaire was designed to assess various aspects of social interaction and cooperation among the preschool children, reflecting key competencies necessary for effective teamwork and group dynamics in the pre-primary setting (Table 2).

Table 2. *Questions, Types of Answers, and Purposes of the Questionnaire*

Nr.	Question	Answer Type	Purpose
1	I enjoy playing with other children at school.	Likert Scale (1 - 5)	Measuring the desire to play with other children.
2	When I play with other children, I usually cooperate well with them.	Likert Scale (1 - 5)	Measuring the ability to cooperate.
3	When I play with other children, I sometimes argue with them.	Likert Scale (1 - 5)	Measuring the frequency of conflicts with other children.
4	I enjoy learning new things in mathematics and science.	Likert Scale (1 - 5)	Measuring interest in mathematics and science.
5	When I learn mathematics and science, I usually understand the concepts easily.	Likert Scale (1 - 5)	Measuring the understanding of mathematical and scientific concepts.
6	When I learn mathematics and science, I sometimes need help from others.	Likert Scale (1 - 5)	Measuring the dependence on external help in mathematics and science.

The first question aimed to gauge each child's enjoyment of playing with peers at school, using a Likert scale to measure their overall enthusiasm for social play. This question provided insights into the children's willingness to engage with others, which is fundamental for fostering a collaborative environment. The second question focused on the children's ability to cooperate during play. By using the Likert scale, this question evaluated how well children work together, which is crucial for team-building and successful group interactions. Understanding their cooperative tendencies helps in identifying how effectively they can function as part of a team. The third question assessed the frequency of conflicts during play. This metric was vital for understanding how often disagreements arise among the children and provides a measure of their conflict resolution skills—a key component of successful teamwork. The next question explored the children's interest in learning new concepts in mathematics and science. By measuring their enthusiasm and engagement with these subjects, the questionnaire aimed to determine their motivation and willingness to explore mathematical and scientific ideas, which are central to the curriculum objectives. Following this, the questionnaire assessed how easily the children grasp mathematical and scientific concepts. This evaluation helped understand their ability to comprehend and integrate new information, which is essential for their academic development. Finally, the questionnaire inquired about the children's reliance on external

help when learning mathematics and science. This question aimed to identify how often they require assistance, shedding light on their independence in problem-solving and understanding.

4. Results

The results of the questionnaire, administered to assess the impact of nature-based activities on children's social and academic skills, indicate several significant changes following the intervention.

For the first question, which evaluated the children's enjoyment of playing with others at school, there was a notable improvement post-intervention. Initially, 12 children expressed enjoyment in playing with peers, while an additional 5 children reported this sentiment after participating in the nature-based activities. Among the 3 children who were neutral on this matter initially, only one remained neutral at the end of the study. This increase in positive responses suggests that the nature-based activities fostered a greater appreciation for social play among the children.

Regarding the second question, which assessed the children's ability to cooperate effectively with peers, there was a marked improvement. Prior to the intervention, 8 children indicated they worked well with others, but this number rose to 12 following the nature activities. Additionally, the number of children who reported working well "sometimes" decreased from 6 to 3, indicating a shift towards more consistent cooperative behavior after engaging in nature-based tasks.

The third question inquired about the frequency of conflicts among children during play. Although conflicts were still present after the intervention, their frequency diminished. Initially, conflicts were reported by a larger group, but post-intervention, only 5 children experienced conflicts. This reduction, despite the increased team interaction, underscores the impact of nature-based activities on improving conflict resolution skills and overall social harmony.

For the fourth question, concerning the children's enjoyment of learning new mathematical concepts, responses were notably more positive after the nature activities. The anticipation of engaging in outdoor games related to mathematics and science increased the children's enthusiasm and motivation for these subjects, reflecting a positive shift in their academic engagement.

The fifth question assessed how easily children understood mathematical concepts. There was an improvement in responses after the nature-based activities. While the intervention may have focused on specific mathematical concepts, the practical, hands-on nature of the activities facilitated a deeper understanding of these concepts among the children.

Finally, the sixth question explored the children's dependence on external help in mathematics. Post-intervention, there was an increase in the recognition of collaborative support. The nature-based activities highlighted the benefits of teamwork, leading children to appreciate collective problem-solving and support from peers. This shift indicates a growing recognition of the value of mutual assistance and collaboration in learning.

Regarding the mathematics test, the initial task "Draw the weather today" showed considerable variability in detail accuracy and consistency among students, with an average score of 2.5. Following the intervention, there was a significant improvement in both detail and precision of the drawings, resulting in an average score of 4.0. This enhancement indicates that the nature-based activities positively influenced students' observational skills and their capacity to visually represent weather phenomena. Similarly, for the task "Draw as many elements as the number indicates," which assesses counting and matching skills, the average score increased from 2.8 to 4.3. This change reflects an enhancement in students' ability to accurately count and correlate numbers with corresponding elements, demonstrating the effectiveness of the nature-based activities in reinforcing numerical skills.

The task "Compare the quantities using these symbols: >, =, <" also showed notable improvement. The average score for this task rose from 2.6 to 4.2, indicating that students developed a better grasp of comparison symbols and their application in evaluating quantities. For the task "Decompose the following numbers," which measures understanding of number concepts and basic arithmetic, the average score increased from 2.7 to 4.1. This improvement illustrates a deeper comprehension of numerical decomposition and arithmetic operations among the students as a result of the intervention.

Lastly, the task “Circle the spring elements,” aimed at assessing students’ knowledge of nature, saw an increase in average scores from 3.0 to 4.5. This suggests that students gained a better understanding of natural elements and their characteristics through the nature-based activities.

To check if the improvement was statistically significant the pretest and posttest results were compared. As the Shapiro-Wilk test shows deviation from normality, the Wilcoxon signed-rank test was used to compare the pretest and posttest results. The results indicate significat inprovement in case of each task and also on the environmental science (item 1 and 5) and mathematics (item 2, 3, and 4) related questions – see Table 3.

Table 3.*Comparing pretest and posttest results of the Mathematics and Environmental Science Test*

Item	**Pretest**		**Posttest**		**W**	**z**	**p**
	M	**SD**	**M**	**SD**			
Item 1	3.08	1.15	3.77	1.01	14.500	-3.379	<.001
Item 5	3.49	0.57	4.30	0.49	0.000	-3.920	<.001
Environmental Science	*6.57*	*1.64*	*8.07*	*1.47*	*3.000*	-3.808	*<.001*
Item 2	3.40	0.82	4.43	0.73	4.500	-3.752	<.001
Item 3	2.63	0.74	4.01	0.75	0.000	-3.920	<.001
Item 4	2.61	0.76	4.03	0.70	0.000	-3.920	<.001
Mathematics	*8.64*	*2.12*	*12.47*	*1.95*	*0.000*	*-3.920*	*<.001*

In summary, the comparative analysis of the test scores before and after the intervention demonstrates significant improvements across all tasks. These findings indicate that the cooperative learning activities in nature effectively enhanced students' mathematical skills and their understanding of both numerical and natural concepts.

5. Conclusion

The introduction of cooperative learning methods in nature, while beneficial, presents several challenges for educators. One of the primary difficulties is allocating sufficient time and resources for the planning and execution of these activities. Effective implementation demands careful preparation and ongoing adjustments tailored to the needs of the children. Teachers must possess a robust understanding of science and mathematics and be capable of conveying this knowledge in a manner accessible to young learners.

Successful integration of cooperative learning in natural settings requires several essential prerequisites. First, adequate training and professional development for teachers are crucial. Educators need to effectively deliver nature-related content and possess the pedagogical skills necessary for applying cooperative learning methods. Second, support from the school and education system is imperative, including a supportive infrastructure and sufficient resources for implementing these methods. Third, access to safe and diverse natural environments is essential for providing children with meaningful learning experiences. Finally, the curriculum must offer enough flexibility to incorporate outdoor learning activities without compromising educational objectives.

The original research question of this study, “To what extent can nature games promote cooperation among preschool children?” was addressed by evaluating the impact of nature-based cooperative games on children’s social and academic skills. The findings confirm that nature games significantly enhance cooperation skills, mathematical understanding, and scientific knowledge among preschoolers. Through nature games, children developed a deeper appreciation for teamwork and collaboration, equipping them more effectively for future academic and social challenges.

Integrating these nature-based cooperative activities into the discipline of "Mathematics and Exploring the Environment" has proven to be an efficient way. As the results demonstrate, children not only achieved expected outcomes in mathematical skills but also showed notable improvements in their social skills. The activities facilitated the development of key mathematical concepts while

simultaneously fostering essential social competencies such as teamwork, communication, and cooperation.

This study underscores the importance of nature as an educational environment. By incorporating nature games into the education plan, educators can create a stimulating and relaxed learning atmosphere that boosts motivation and engagement. The integration of nature-based activities into educational practice can significantly enrich learning experiences and support the holistic development of children.

In conclusion, nature games represent a promising approach to advancing both social and cognitive skills in children. Further exploration of various types of nature games and their effects on different aspects of student development is warranted. Future research should also examine the long-term impact of these activities on learning and social development to fully understand their potential benefits.

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